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THE BOTANICAL GAZETTE

September 1912

Editor: JOHN M. COULTER

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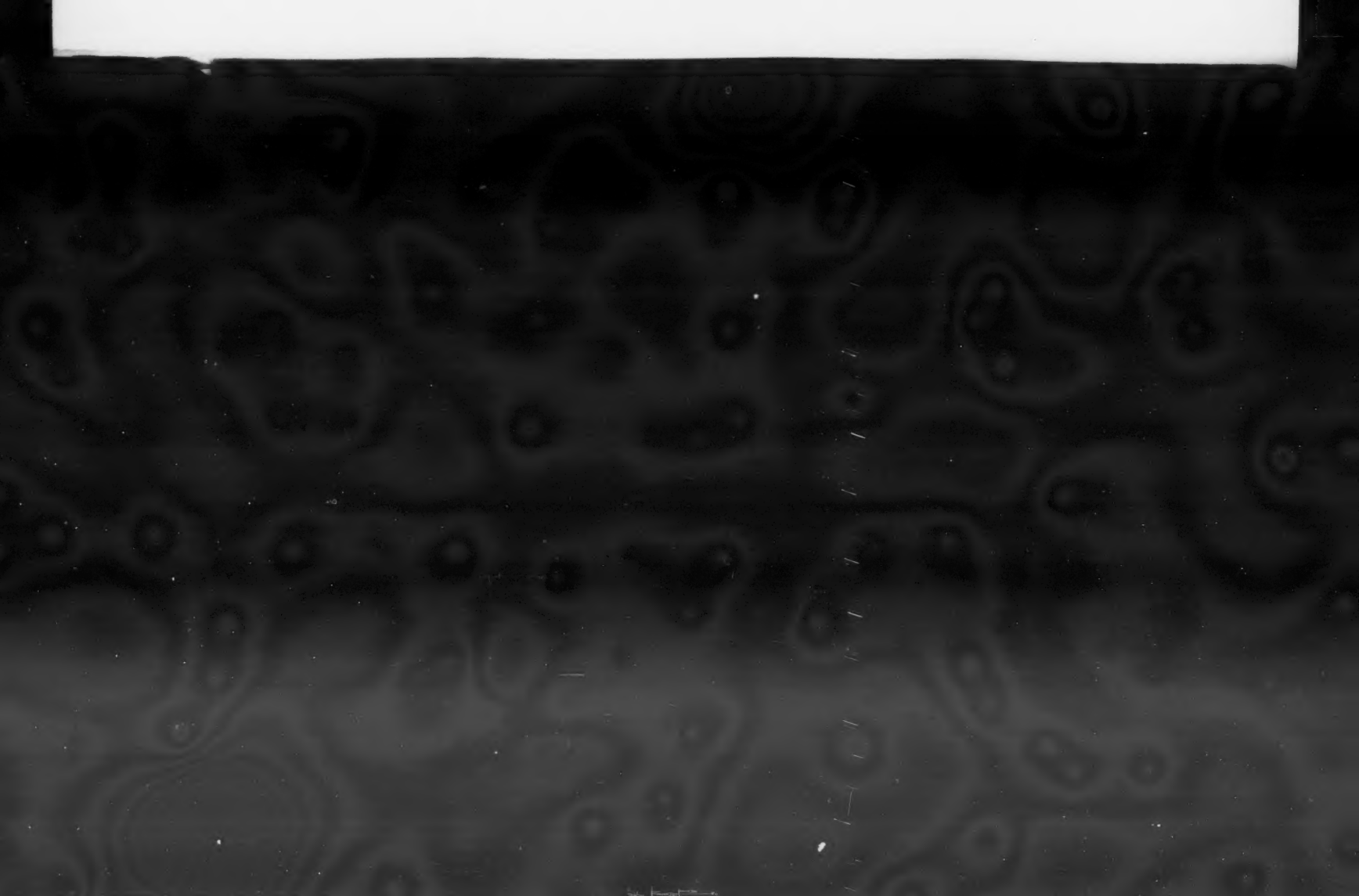

VOLUME LIV NUMBER 3

THE

BOTANICAL GAZETTE

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THE LIFE HISTORY OF ANEURA PINGUIS

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 159

GRACE L. CLAPP

(WITH PLATES IX–XII)

Historical

In his classical study of liverworts, LEITGEB (**19**) has given a comparative treatment of the genus *Aneura*. Stages of development chosen from several species picture the life history of the genus rather than that of any one species from spore to spore. HOFMEISTER (**13**) earlier described the apical cell and sex organs of *Aneura pinguis*, and KNY (**15**) worked out in an elaborate scheme the segmentation of its apical cell. LE CLERC DU SABLON (**18**), GOEBEL (**10–12**), CAMPBELL (**3**), and CAVERS (**4**) have since added facts, but gaps have been left in the continuous development, chiefly in the embryogeny and in the growth of the sporeling.

Material

Material of *Aneura pinguis* was collected by Dr. LAND at Xalapa, Mexico, in the autumns of 1906, 1908, and 1910. The region around Chicago has offered abundant supply for field study. The plants were killed in the field in Flemming's fluid (weaker), in alcohol (50 per cent) and formalin, and in chrom-acetic acid without osmic acid. Following the close series of alcohols in dehydration, the material imbedded in paraffin was cut in sections 3–10 μ thick. Safranin and anilin blue, Haidenhain's iron-hematoxylin with and without Magdala red, and Flemming's triple stain were used for

stains. Shrinkage in the young embryo and resistance to infiltration of the mature capsule were the chief difficulties met.

Thallus

SCHIFFNER (**23**) describes *Aneura pinguis* as a cosmopolitan species, strictly dioecious. LAND reports the growth of the species on decayed fallen logs in the rain forest as most luxuriant. The plants exceed only slightly, however, those growing in the hydromesophytic habitats of Chicago. On fallen hemlock logs in shady ravines and on the mossy edges of pine-oak dunes bordering sloughs the plants form a close mat. Wherever moss forms a humus layer along the lines of seepage of the clay bluffs along Lake Michigan, the thalli are also found. In the prairie meadows *Aneura pinguis* often extends half an inch on *Typha* and *Acorus* leaves or grows on clumps of exposed grass roots. In all these places moisture, diffused light, and fairly low temperature are the favorable conditions for its growth. Plants grow fairly well in the laboratory when these conditions are imitated.

Aneura pinguis is strictly dioecious, but both kinds of plants grow side by side in the field, often with margins overlapping (fig. 1). In general the thallus is a flat ribbon-shaped plant closely appressed to the ground, with frequent branches, and slight indentations along the margins. While it averages 5–7 mm. in width, it may be reduced when growing in a moist chamber with light from one side in the laboratory to less than 2 mm. (NĚMEC **21**).

The thallus consists of compact cells, unequally elongated in the direction of the main axis of the plant. Although it lacks a midrib, the plant is usually thicker along the center, thinning out toward the lateral margins. All the cells contain chloroplasts at some time and the plastids often have 5 or 6 starch grains. Ordinarily it is 10–12 cells thick. There is no definite differentiation into tissues, but the superficial layer is clearly composed of smaller cells with a larger number of chloroplasts. This dorsal "small-celled epidermis" has undergone one more division, longitudinally and transversely vertical, than the layers beneath (fig. 2). Plants in the shade appear succulent and are deep emerald green in color. The numerous chloroplasts are found dividing as often as in *Funaria* or *Elodea*.

On the ventral surface rhizoids (figs. 13–15) and mucilage hairs (fig. 12) indicate slight cell differentiation. The rhizoids contain chloroplasts at first like the other superficial cells (fig. 13). Such cells project slightly, elongate, the chloroplasts disappear, and the rhizoids look like root-hairs. As they grow longer the position of the nucleus changes and the cytoplasm varies in amount and distribution. Both are near the somewhat thickened tip when the rhizoid is old. The rhizoids resemble root-hairs in that they become irregularly lobed in contact with soil particles (fig. 15) and flatten out in a most deformed way against other thalli and bark. BOLLETER (**2**) notes this same lobing in *Fegatella conica* and it is common among liverworts. The length and number of rhizoids varies greatly. In contact with an underlying thallus or bark they are very short (0.09–0.16 mm.); in soil and moist air they average less than 1 mm., and only occasionally reach 2 mm. On closely appressed plants the rhizoids are numerous and scattered; in soil they grow along the central axis but are never definitely localized. Irregularity may come from fungi in the rhizoids, and again they may be as straight as if uninfected. In no case were the lobes of the rhizoids cut off by walls.

Gemmae have been described by many for *Aneura pinguis*. In the material at hand no gemmae were found. If they are characteristic of this species, their absence must be due to the conditions under which the plants grew. EVANS (**7**) has found in species of *Metzgeria* that gemmae are not likely to appear when the plant is growing luxuriantly. This would account for their absence in the field, but one might expect them to appear on plants grown under less favorable conditions in the laboratory.

Increase in the number of plants is brought about, as in many other thallose liverworts, by the dying away of older parts, when branches become the main axes of new individuals.

Aneura pinguis produces three kinds of branches, the ordinary vegetative ones and those bearing the two different sex organs. Such branches have their origin in the segments of the apical cell. All of the descriptions of this cell agree that it cuts off segments on two sides alternately right and left (figs. 3–11). Vertical sections through any of the marginal indentations which indicate

growing points show clearly that its longer axis is the vertical one (fig. 2).

Very rarely at the forward end of the thallus can only one apical cell be found (figs. 5, 6). Usually two indentations are separated by a narrow marginal projection and each sinus contains two apical cells (figs. 9–11). One set carries on the main axial growth, the other produces a branch. The apical cell of the branch originates in a segment of the axial apical cell by a curved vertical wall bent to the right or left so that it strikes the wall of the segment opposite the last cutting one.

The more rapidly growing dorsal surface carries the apical cell to the ventral side (fig. 2). The wall-formation in either direction, therefore, shows an obliquity which later is distinctly vertical or horizontal. The primary segment is divided by a vertical transverse wall into an inner posterior cell and an outer anterior marginal one. Walls parallel to the surface come in now, followed by more vertical ones. The order of vertical, transverse, or longitudinal does not seem fixed. Clearly these three directions give thickness, length, and width to the thallus.

If the growth of two apical regions is nearly equal, the thallus appears dichotomously branched; if one grows faster, the other is recognizable as an indentation on the lateral margin, where it may remain growing very slightly if at all; or if the main axis be injured, it becomes the apical region of the main thallus, growing rapidly.

Characteristic of the apical cell are the mucilage hairs borne on the ventral surface of the thallus (fig. 12); 6–10 of them curve inward and upward around the growing point. KNY and LEITGEB describe the mucilage cells as bearing no direct relation to the thallus in arrangement. They show an alternation, however, corresponding to that of the apical cell segmentation. The superficial cell from which the hair originates first projects from the surface, and then divides into two cells. The basal inner cell retains its plastids permanently; the chloroplasts of the outer one, after some growth, are transformed into a mucilaginous stuff, which stains very deeply. These are the hairs which are sloughed off as the thallus grows. The basal cell divides like any superficial cell. Apparently it is the posterior ventral surface cell, cut from the

primary segment by a vertical transverse and horizontal wall, which produces it.

Sex organs

ANTHERIDIA.—The antheridia of *Aneura pinguis* are borne in the upper surface of lateral branches which occur singly, in groups of three, or occasionally in groups of two. On the branch their arrangement is extremely regular, in two alternating rows corresponding to the segments of the apical cell. They appear imbedded because of the rapid marginal growth of the surrounding cells.

LEITGEB'S diagram for their arrangement in *Aneura palmata* holds true also for *Aneura pinguis*. After the division of the primary segment into an outer marginal and an inner posterior cell by a vertical transverse wall, and after horizontal cleavage of the latter into a dorsal and a ventral cell, the dorsal cell by a vertical longitudinal division forms an inner (toward the median axis of the thallus) and an outer (toward the lateral margin) cell. The inner by a transverse vertical cut divides into two cells, the anterior of which gives rise to the antheridium. This dorsal superficial cell (the antheridium initial), containing a large nucleus and abundant cytoplasm, enlarges and projects (fig. 16). It divides into two cells, the outer of which, by a horizontal wall, forms a stalk cell usually dividing once at least, and the antheridium mother cell (fig. 17).

The method of development follows the *Jungermannia* type. First a vertical wall divides the outer cell into two equal halves (fig. 18). By two vertical intersecting walls in each half, a wall layer of four cells surrounds two central cells—primary spermatogenous cells (figs. 22, 23). By rapid growth the antheridium becomes spherical and appears transparent (fig. 26). Its wall cells, however, contain chloroplasts which persist until the sperm mother cells are distinguishable. The wall cells of the upper half grow noticeably larger than those of the lower half.

No definite cytological study of spermatogenesis was made, but some few points were noted. No centrosome was evident during any division of the spermatogenous cells. The diagonal division of the sperm mother cells separates them by a membrane which

stains as deeply as does the cell wall of the mother cell. The oval nucleus stains deeply and soon occupies one end of the protoplast (fig. 27). At the other end, a dark spot appears in the cytoplasm—the blepharoplast—which gives rise to the cilia. The nucleus in its growth elongates, soon making a turn around the cytoplasm. The cilia are not easily distinguished from the coils of the nucleus. Beside the beak of cytoplasm, anterior to the nucleus from which the cilia extend, a rounded mass is left at the posterior end of the sperm. This is a mechanical hindrance to the movement of the sperms when the cell walls are transformed into a mucilaginous substance and the sperm is often twisted into small spirals on its own axis (fig. 27). These disappear as soon as space is given, and at the time of shedding the mass of cytoplasm at the base is also gone. The body of the sperm is very long and averages about 2.5 times that of the cilia. Cilia 35.2 μ and sperm 88.7 μ, in rough figures, were the measurements of the longest sperms squeezed out of the antheridium before it had burst naturally. Probably when shed in the field they have grown somewhat longer.

The antheridia begin to form early in the spring. They develop in acropetal succession until August, when many of the branches, as has been noted (LEITGEB, CAMPBELL), continue vegetative growth. The last antheridium formed is sometimes not imbedded, but superficial, owing to the rapid elongation of the thallus.

ARCHEGONIA.—*Aneura pinguis* bears its archegonia also on the dorsal surface of distinct lateral branches (fig. 28). Such plants have conspicuously light green filamentous outgrowths, varying in length and width on the lateral margins. These are caused by the more rapid growth of the thallus edges of the main axis or of the lateral branch. Again, there may be from one to three branch primordia; usually, however, one outstrips the others in development. Like the antheridia, the archegonia are regularly arranged in two rows, alternating according to the apical cell segmentation. The division of the primary segment is as usual. The first dorsal superficial cell is the archegonium initial. In order of development it follows the general liverwort type. Three vertical intersecting walls surround a central cell from which a cap cell is cut off by a horizontal wall (fig. 29). The central cell gives rise to four neck

canal cells, a ventral canal cell, and the egg cell. The archegonium wall has two layers of cells (figs. 32, 33). The 4–6 canal cells are of short endurance; their walls break down and the cytoplasm and nucleus are transformed into a mucilaginous substance. The egg cell is large and round, its cytoplasm containing many starch grains (fig. 33). When the cap cells bend back, there is a clear passage made in the neck to the egg. Fertilization was not observed.

As soon as fertilization has occurred, the neck and venter cells divide rapidly, and the whole branch is a thick cushion of cells projecting beyond the margin of the thallus. Usually only one embryo grows on a branch, and where two appear they probably belong to two branches. Two have been reported, however, in one calyptra (COKER **6**). Occasionally archegonia, immature and after the egg has been fertilized, are carried with the filaments to the top of the calyptra in its growth. LEITGEB thinks more trichomes are produced on the torus, but this seems unlikely, for many are sloughed off as it develops. Some new rhizoids do grow at the bulbous base.

Sporophyte

The first division of the egg is a transverse one into epibasal and hypobasal cells (fig. 34). The hypobasal cell has been said either to form a few divisions or to grow into a lobed haustorial cell (LEITGEB **19**). It distinctly becomes a true haustorium (figs. 35, 36), rhizoidal in form. Both cells elongate rapidly; the haustorium sometimes lobes and sometimes remains straight. The epibasal cell is divided by a horizontal wall into two cells (fig. 35) containing abundant cytoplasm, many plastids, and large nuclei. In this three-celled stage disorganization of the cells of the calyptra around the base of the suspensor is striking. The uppermost cell divides again by a horizontal wall, so that a filament of four cells is formed, including the haustorium. Vertical walls now come in, so that there are three rows of quadrants (fig. 36).

The lowest tier next the haustorium now forms two rows (figs. 37, 38), its vertical and transverse walls having no definite sequence. It corresponds to the foot, and the cells form at first a more compact

mass than the slender ones above. The uppermost cell arising in the epibasal row divides to form the capsule; the middle originates the seta, probably by its intercalary growth as LEITGEB has suggested. When, therefore, the seta consists of three or four tiers of cells, the capsule is definitely differentiated. It consists of two rows, each of eight cells. Periclinal walls have cut out a wall layer one cell thick (fig. 38), leaving a central sporogenous tissue of eight cells. The lower four divide by horizontal and vertical walls; the upper also divide, but form only a group of sterile cells—a cap, later continuous with the elaterophore. The wall of the lower half becomes two layers by periclinal divisions not at all simultaneous (figs. 39, 40). The difference in rate of growth from now on is a striking feature of development in the capsule (LE CLERC DU SABLON **18**). It first shows in the contrast between the lower and peripheral region and the upper central part. The contents of the cells differ in size of nuclei and amount of cytoplasm. Cell divisions are in every direction. The capsule changes from spherical to oval and elongates rapidly (fig. 41). This difference in rate of growth accompanies the formation of the elaterophore, but what determines the rate? The more slowly dividing cells of the upper central region begin to elongate, and the elaterophore is outlined (fig. 42); its cells have smaller nuclei and less cytoplasm. Although cell divisions are fewer along its margin, they must still be considered sporogenous tissue. Diagonal divisions and radial arrangement of diamond-shaped cells indicate elongation of the capsule. Cells continuing the axis of the capsule between the elaterophore and the base are still rectangular, like those of the elaterophore except in size of nuclei.

Differentiation among the spindle-shaped cells is the next evidence of separation of the sporogenous tissue into elaters and spore mother cells (figs. 43–50). While in the central axis the elongated diamond-shaped cells appear to form continuous rows to the base, in the radial peripheral regions this is more uncertain. The next stage, and a most unsatisfactory one for study, shows a partial transformation of the walls of the elaters and of the spore mother cells. The elaterophore forms a central cylinder of long prosenchymatous cells, the marginal ones of which have a free tip.

They contain plastids with starch. The protoplasts of the elaters and spore mother cells are outlined by a definite membrane at a distance from the wall. The space between, however, shows less well defined strands. The nucleus of the elater is large (figs. 44, 45), at the center, extending well across the diameter of the cell. There are plastids in the elaters, and BOLLETER (**2**) considers the elaters in *Fegatella* feeders of the spore mother cells because the starch disappears from the elaterophore about this time. The spore mother cells also have very large nuclei and the form of the cell is irregularly rectangular to triangular.

The difference in rate of growth noted before between the peripheral and central regions is much more evident at this stage. The four lobes of the spore mother cells are well rounded toward the outer portions of the capsule, while those at the center are just beginning to be distinct. The nucleus with a clear nucleolus lies at the center of the lobed cell (fig. 46). Two successive divisions of the nucleus form the tetrad of spores.

The cell plate becomes continuous with the deeply staining membrane of the lobes. This membrane soon differentiates into another substance, being added to from the interior where its outline is very irregular. Centrally between the two margins staining indicates lines of some substance which grow out to the outer margin, forming at first irregular projections. Meanwhile, within the protoplast a cellulose layer forms. When the spore is mature the two wall layers are not distinct (figs. 51, 52). The protoplast containing chloroplasts seems to be surrounded by a single brown wall with echinate projections. During this time the elaters have changed. The cytoplasm has come to form a spiral along the wall and a broad brown thickening takes its place (fig. 52). Two spirals are not rare and the elaters are often branched (JACK **14**). Probably examination of the chemical changes taking place in the spore coat would find them similar to those BEER (**1**) has found for *Riccia*.

The cell walls of the elaterophore are thickened in a narrow single spiral. The two wall layers have ring thickenings in the sterile cushion at the apex, and in the two upper layers of cells of the seta irregular thickenings are found. The lines of dehiscence are

remarkably distinct in cross-section (fig. 54), for the walls do not change on that side, but remain thin, composed of cellulose.

The seta, measuring about 2 mm. in length, would be described as having a club-shaped foot if it can be called a foot. Even when the seta consists of a few tiers of cells, the glandular appearance at the base is striking. Tissues of the calyptra and seta disorganize so that at the base of the seta there are always some glandular cells and others very much crushed. During its growth the bulbous base of the gametophyte and sporogonium has turned from a horizontal to a vertical position.

The capsules dehisce progressively along the thallus from early spring (March) through May. GOEBEL (**10**) has well described the dehiscence and shedding of spores in *Aneura palmata*. The seta elongates rapidly (NĚMEC **20**) from 2 to 30 and more mm., in the field often twisting on its own axis. Individually its rectangular cells lengthen from 60 μ to 500 and 600 μ. This pushes the capsule far beyond gametophyte and calyptra. Along the well marked lines between the valves, about one-third of the way from the tip at the greatest width of the capsule, a splitting begins. The crack lengthens until with a jerk the valves are bent back. Some spores are freed now, but the majority are shed by the next movement of the valve, when its fourth of the elaterophore springs upward 45° or more. Spores and elaters fall together, the tetrad often complete.

Germination of spores

Plants with capsules about to shed were brought from the field March 23, April 15, May 17, and May 20, and put on wet cotton under bell-jars or in large Petri dishes. Spores were sown as soon as the capsules burst. On sterilized cotton the spores (averaging 60–68 or 70 μ) are soon lost. A better medium and more easily examined under the microscope is made by putting a layer of heavy white filter paper over wet cotton in a Petri dish. Porous clay plates are also good. Drop cultures in 0.5 and 1 per cent cane sugar, 2.5 and 3 per cent glucose, 0.5 and 1 per cent lactic acid, 0.3 and 0.6 per cent Knop solution, vegetable lipase, distilled water, all died after reaching the two-celled stage. The excessive amount of moisture was one cause of this, for cultures made at the

same time on cotton with distilled water and 1 per cent cane sugar lived. On moist cotton in the sunlight the spores died in the one-celled or two-celled stage. Other cultures, therefore, were kept in a room with the window open, so that the temperature varied roughly with that outside, and the light was kept diffuse by the window shade. Sowings were made on sterilized clay, sand, sphagnum, humus, and sand, and kept under bell-jars. Cultures on rotten wood were spoiled by *Pencillium*. Although the pots containing the soils were scrubbed, dried, sterilized over night in a drying oven above 115° and again with the soils in an autoclave, many became infected with a species of *Chaetomium*. This could have come about when spores were taken out for examination. The accompanying table records some of the data.

Sowing	Final examination	Time	Medium	Condition of spores
March 23...	June 23	3 mos.	H_2O on cotton	2-celled to all stages (fungi)
April 15...	June 17	2 mos.+	clay	1–3-celled; majority 2-celled
April 15...	June 17	2 mos.+	H_2O on filter over cotton	majority 2-celled
April 6...	June 19	2 mos.+	H_2O on filter over cotton	2-celled
May 5...	June 19	1 mo. +	H_2O on filter over cotton	2-celled
May 5...	June 17	1 mo.	soil	2–7-celled (fungus)
May 21...	June 21	1 mo.	sand	2-celled
May 21...	June 21	1 mo.	1% cane sugar filter on cotton	2-celled
May 29...	June 21	1 mo. −	soils	1–4-celled (Chaetomium)
May 29...	June 21	1 mo.	H_2O filter on cotton	2-celled
May 29...	June 21	1 mo.	filter over soil	2–4-celled (fungus)

This rough table shows that the rate of development is variable and slow. The spores of March 23–June 23 were shed in a heap on the moist cotton in the moist chamber containing the plants from the field. Here were found two-celled stages and thalli with branches. Uninfected plants have reached at most 4 and 5 cells, while those with fungi have mature thalli. This difference is apparently due to some change caused by the fungus.

LEITGEB (**19**) describes the germination of *Aneura pinguis* and *A. palmata*, but figures only the early stages of *A. palmata*. He

says that the spores enlarge strikingly at first, and by one-sided growth a filament is formed which elongates by apical growth, forming a cylindrical body. This body branches and in the tip cell of the main axis and its branches the typical apical cell of the mature thallus arises.

In *Aneura pinguis* the spores at shedding contain chloroplasts as mentioned above (fig. 51). The spore does increase rapidly in size from 60 and 70 μ to 90 and 100 μ in a few days. The plastids are grouped somewhat at one side, where the cell begins to elongate into a slight projection. A wall divides the spore into two unequal cells (fig. 56) (this may happen within 1 or 2 weeks); the smaller one grows until it equals the sister cell. The exospore has not been split, but has elongated and surrounds the two cells (figs. 57, 58). The younger cell is now divided unequally by a vertical wall bent slightly toward the long axis of the cell (figs. 59, 60). It soon grows as large as the cell from which it was cut off, and the division could easily be mistaken for an equal one. This division may also be horizontal, resulting in a dorsal and a ventral cell. The apical cell may originate in either one of these two cells, probably the better lighted one (PEIRCE **22**, LAMPA **16** and **17**, GOEBEL **10–12**, BOLLETER **2**, SCHOSTAKOWITSCH **24**). This second or third wall can then be considered the one which marks out the apical cell.

Only one sporeling was found where the exospore had split and a filament of five cells had grown (fig. 71). The next division comes when the last cell cut off equals that from which it was cut, and the new wall again is a vertical one inclined toward the axis of elongation (fig. 61). This mode of development continues up to the four- and five-celled stage. The only difference between this apical cell and that of the mature thallus is the longer time interval between the segmentation and the division of the segments. In this four- and five-celled stage the echinate projections of the exospore are still present, at a greater distance apart and finally disappearing. The mass of cells looks slightly as has been pictured for *Lejeunia serpyllifolia* (CAMPBELL **3**).

This then reduces *Aneura pinguis* to the condition described by GOEBEL (**12**) for *Metzgeria furcata*, where the filamentous stage or *Vorkeim* consists of one or two cells. The branched filaments are

lacking, which must depend upon the conditions of light and moisture under which they are grown.

Another interesting fact connected with the development of the spore is that the fungus plays some part in it when present. Where the spores fell from the capsule and germinated on the cotton, and in another case where the capsule did not open wide but spores in the line of the valves germinated, a fungus was found infecting the plants. These sporelings were all past the two-celled stage (figs. 64–66). The better lighted thalli were forked, possessing mucilage hairs and rhizoids. In whatsoever way the fungus affects the plant, development at least is hastened. Fungi have been noted in many leafy and some thalloid liverworts (NĚMEC **20,** BOLLETER **2,** GARJEANNE **8,** CAVERS **5**), but only in one case does GARJEANNE note a fungus with the spore, and then only as near it.

The infection begins in any cell of the sporeling (figs. 64–66) and extends irregularly along the lower surface. Large knots of hyphae are found in the cells. At first the cells are not killed, fungus, plastids, and nucleus all being present. Gradually the plastids disappear but the nucleus remains longer. In cells adjoining and near to the infected ones, starch of the plastids has been transformed into dextrine.

A majority of the plants of the field are infected irrespective of habitat. One would like to know whether spores are also infected early or whether the laboratory conditions were such as to favor infection. It is hardly probable that any such relation exists between spores and fungus as BRUCHMANN has found for species of *Lycopodium*. It is more likely, as GARJEANNE thinks, a chance condition, and not at all an endophytic fungus of mycorrhiza plants. Thalli from the field usually have the fungus a short distance behind the actively growing region, and sometimes extending along two-thirds of the dorsal surface. Is it possible that this is one of the main causes for the dying back of the thallus?

Rhizoids are commonly filled with strands of the hyphae (fig. 68). Infection of the rhizoids commonly occurs from the thallus, and when chloroplasts are still present. The elaborate pseudo-parenchyma of fungi described by NĚMEC (**20**) at the base of the rhizoids is lacking, but there are knots of hyphae. Rarely, also,

are the rhizoids as deformed by the fungus as by the obstacles in their path of growth.

Inoculations of pure cultures have not been made because of the desire to get as many sporelings as possible to develop mature thalli. Some of the fungi obtained pure were a species of *Fusarium*, *Cephalothecum roseum*, a species of *Alternaria* and of *Gloeosporium*, and an unidentified one which grew with *Pencillium* in an impure culture. GARJEANNE has found that more than one species may be present at the same time in a rhizoid. It will be interesting to know how many of the above can infect the spores.

Summary

1. The gametophyte of *Aneura pinguis* is a simple, slightly differentiated thallus.

2. Archegonia and antheridia are borne on lateral branches of dioecious plants; they develop according to the *Jungermannia* type.

3. The sporophyte of *Aneura pinguis* is highly specialized. One-half of the embryo at its first division forms a haustorial cell; from the other half capsule, seta, and a temporary foot develop. Sterilization of the tissue of the capsule occurs at three periods: (1) the wall and apical cushion are cut out; (2) the elaterophore is defined; (3) sporogenous tissue is differentiated into elaters and spore mother cells.

4. The capsule splits by four early defined valves. The spores are echinate and contain chloroplasts at maturity.

5. The protonemal stage is reduced to one or two cells. The spore coat incloses the very young sporeling.

6. The mature thallus often contains a fungus. Infection takes place in some sporelings as early as the two-celled stage. Rhizoids may be infected from the thallus.

7. No gemmae are found on *Aneura pinguis*. New plants are produced by the dying back of the old thallus.

Acknowledgments are due Professor JOHN M. COULTER and Professor W. J. G. LAND, under whose direction this work was done.

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EXPLANATION OF PLATES IX–XII

FIG. 1.—Sketch of dioecious thallus.

FIG. 2.—Vertical longitudinal section through apical cell; ×505.

FIGS. 3–8. Serial horizontal section through apical cell; ×830.

FIG. 9.—Horizontal section of thallus, showing two apical cells; ×505.

FIGS. 10, 11.—Horizontal section of thallus showing two apical cells in one sinus; ×830.

FIG. 12.—Young mucilage hairs; ×830.

FIG. 13.—Young rhizoid with chloroplasts present; ×830.

FIG. 14.—Young rhizoid infected by fungus from within; ×830.

FIG. 15.—Rhizoids with and without fungus, showing irregular form; ×175.

FIG. 16.—Vertical section through antheridium initial; ×505.

FIG. 17.—Vertical section, showing antheridium initial divided into stalk and antheridium proper; ×830.

FIG. 18.—Vertical section through antheridium, showing first vertical wall; ×505.

FIG. 19.—Stages of development in antheridium, showing wall and spermatogenous cells defined; ×505.

FIG. 20.—Vertical section through antheridium, showing early divisions of the spermatogenous cells; ×830.

Figs. 21–24.—Horizontal sections through the antheridium, showing its development; ×1650.

FIGS. 25, 26.—Vertical sections through older antheridia, showing stalk cells, and fig. 26 showing the development of the tissue around the antheridium; ×505.

FIG. 27.—Stages of development in the sperm; ×2800.

FIG. 28.—Horizontal section through an archegonial branch, showing numerous archegonia; ×505.

FIG. 29.—Vertical section through young archegonium; ×830.

FIG. 30.—Vertical section through older archegonium; ×830.

FIG. 31.—Horizontal section through archegonial neck; ×830.

FIG. 32.—Vertical section through mature archegonium; ×830.

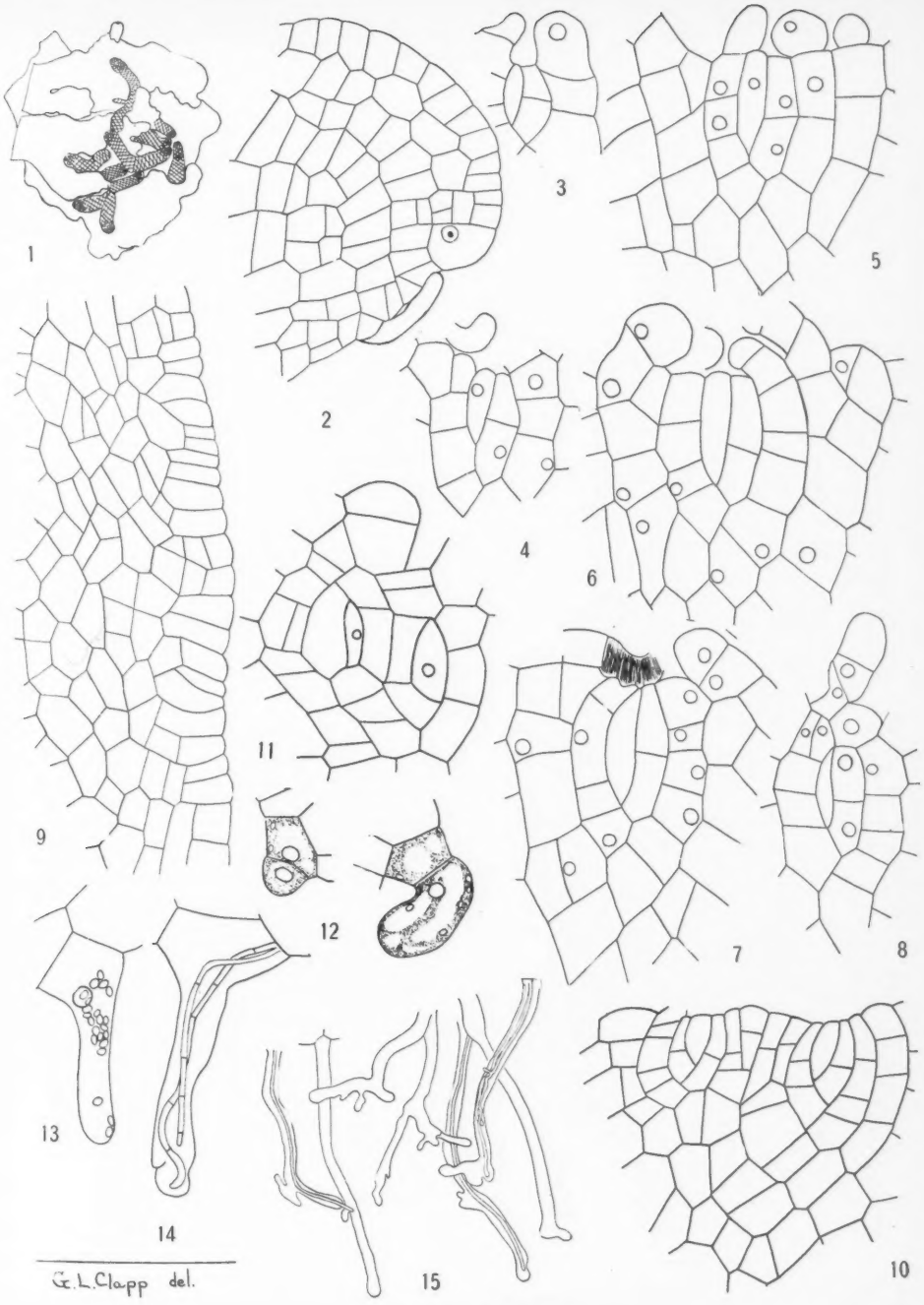
FIG. 33.—Vertical section through archegonium, showing canal cells disorganized; ×830.

FIG. 34.—First division of the young sporophyte; ×1040.

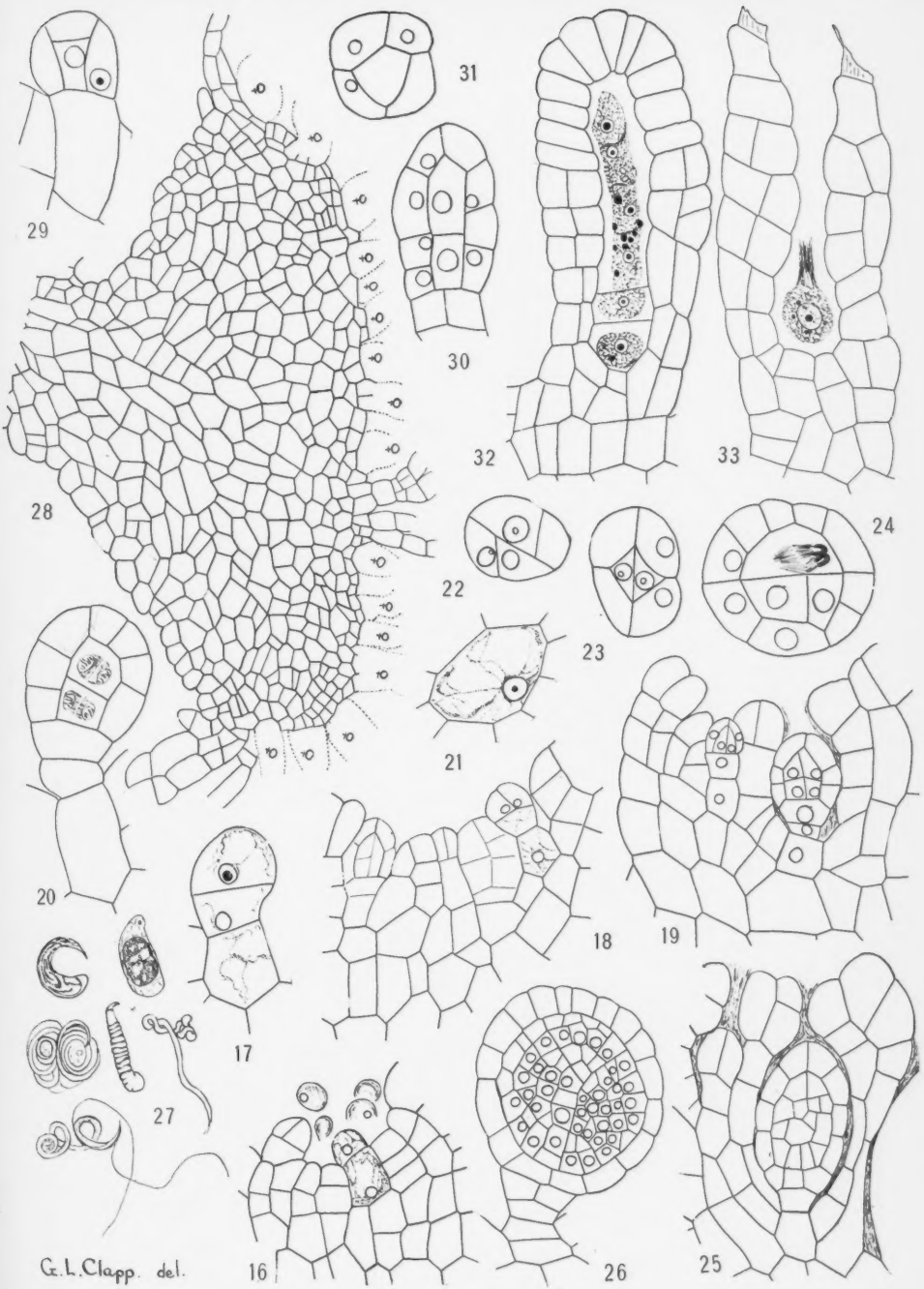
FIG. 35.—The haustorial cell of the sporophyte, well elongated, and gametophyte cells disorganizing; ×1040.

FIG. 36.—Haustorial cell more elongated; the sporophyte proper composed of four cells; ×1040.

FIG. 37.—Foot, seta, and capsule region of the sporophyte marked out; ×1040.



CLAPP on ANEURA



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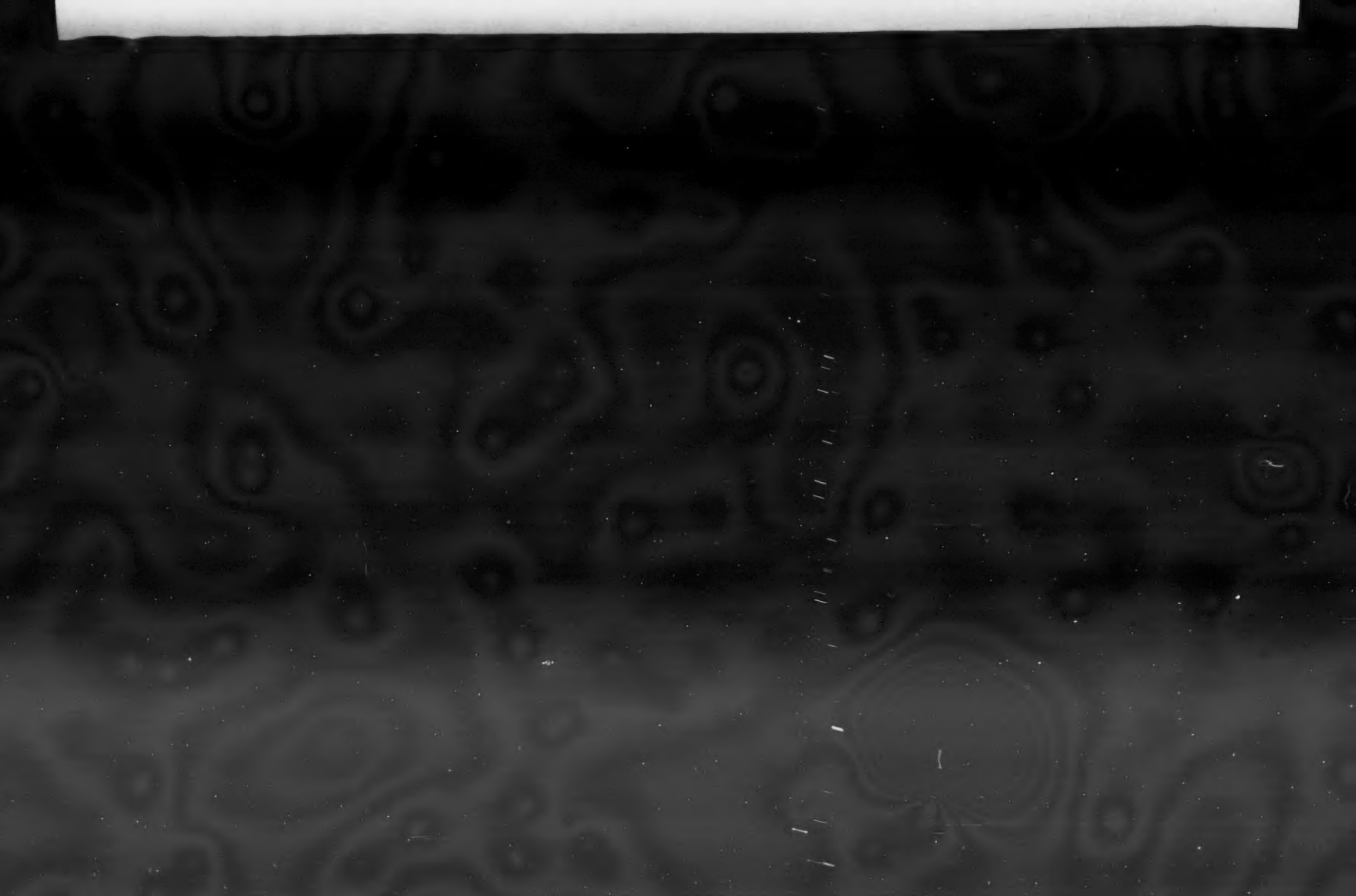

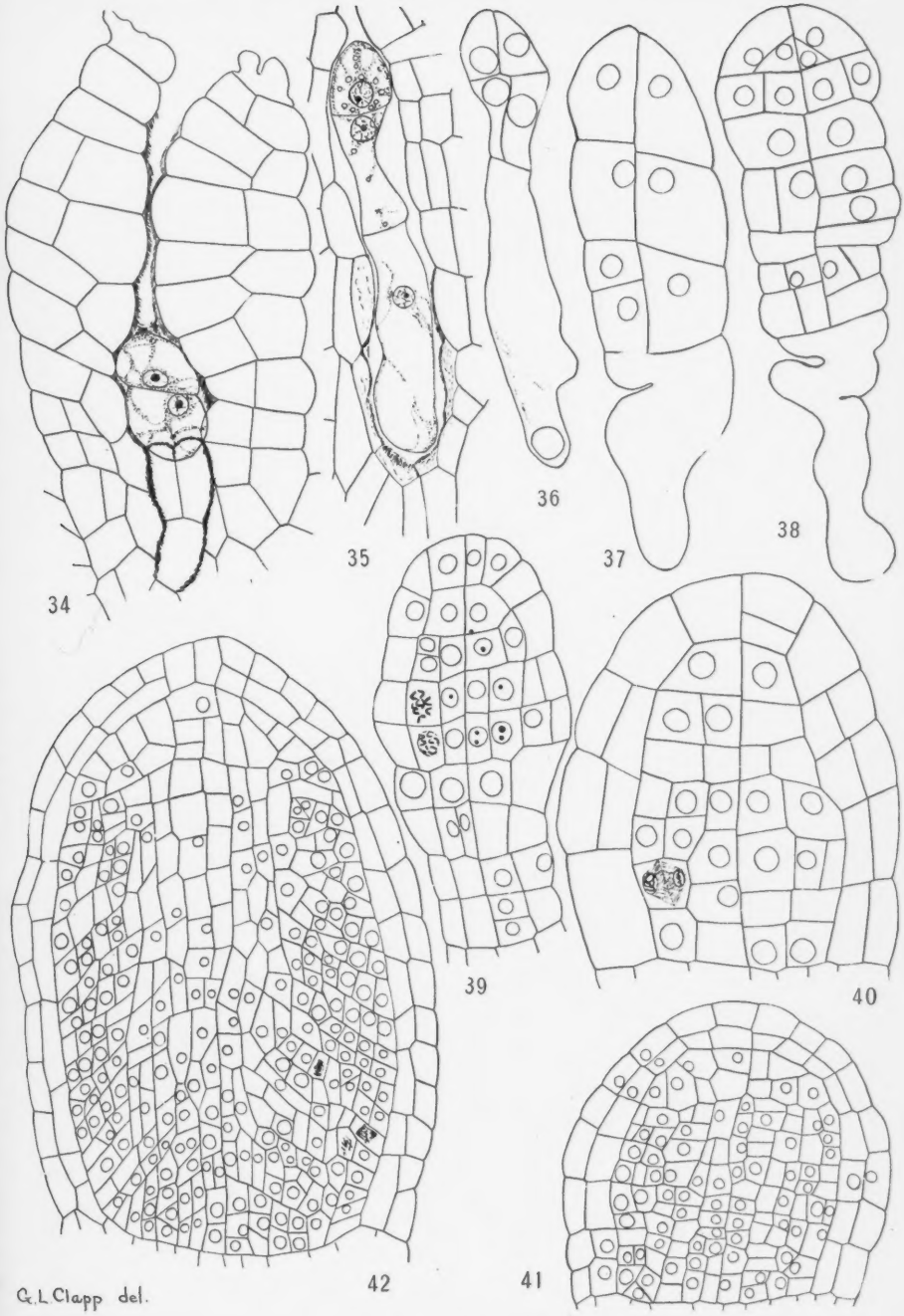

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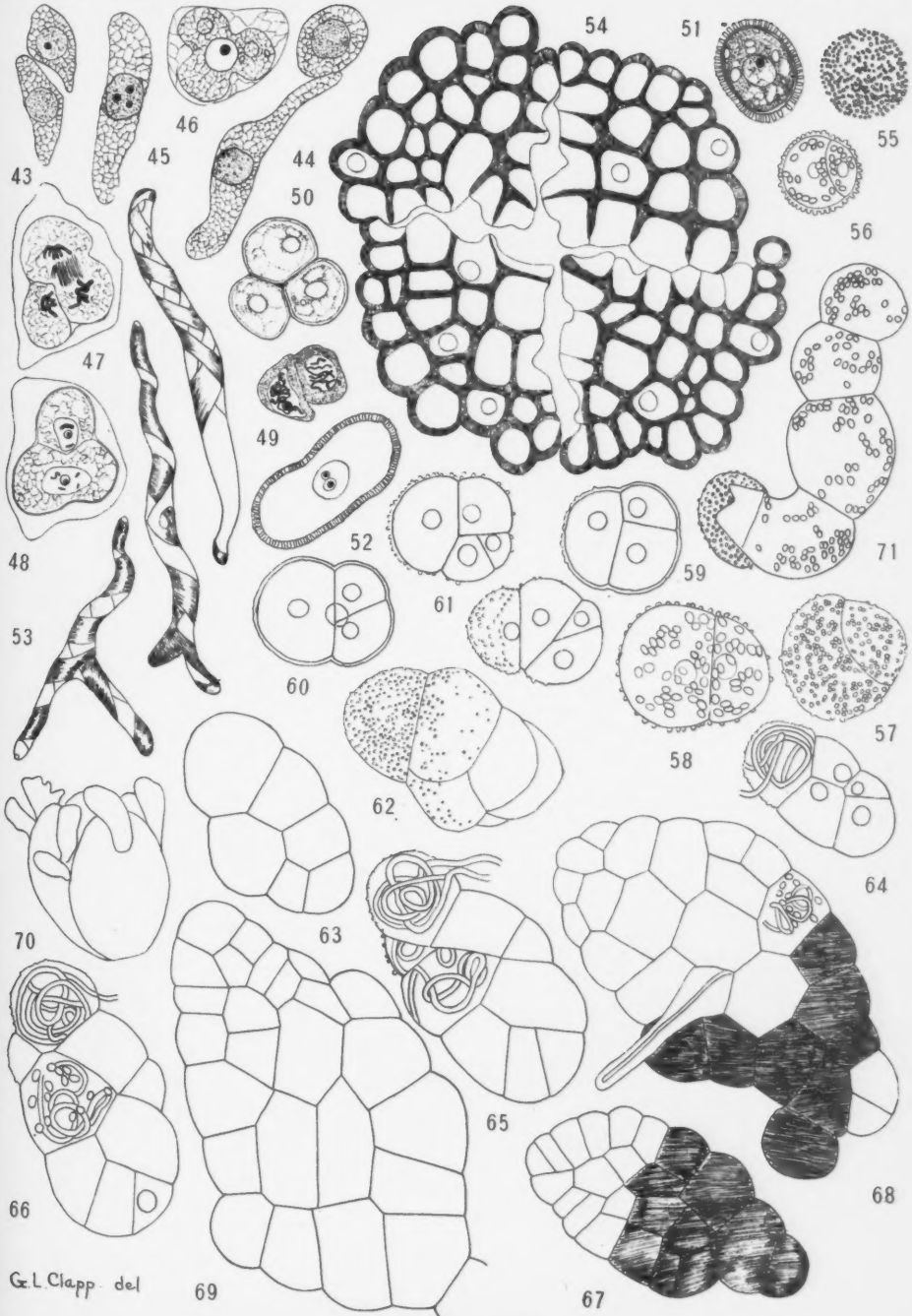

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FIG. 38.—The primary wall layers and sporogenous tissue differentiated; ×1040.

FIGS. 39, 40.—Older stages of the sporophyte; the cushion of sterile cells and sporogenous tissue differentiated; ×1040.

FIG. 41.—Older sporophyte showing the meristematic region of the sporogenous tissue; ×505.

FIG. 42.—Delineation of elaterophore beginning; ×505.

FIGS. 43–50.—Young elaters and spore mother cells; ×1650.

FIG. 51.—Mature spore; ×1650.

FIG. 52.—Occasional form of mature spore; ×1650.

FIG. 53.—Branched elaters; ×830.

FIG. 54.—Cross-section of capsule, showing lines of dehiscence; ×830.

FIG. 55.—Germinating spore, swollen; ×830.

FIG. 56.—First stage of germination; ×830.

Figs. 57, 58.—The same stages a little later; ×1040.

FIGS. 59–63.—Stages in germination; spores developing on wet cotton; uninfected by fungi; ×830.

FIGS. 64–66.—Apical cell of thallus defined; fungus present; ×830.

FIGS. 67, 68.—Older thalli showing fungus present in darkened region; ×830.

FIG. 69.—One of the larger thalli, developed in capsule shown in fig. 70; ×830.

FIG. 70.—Capsule showing thalli from split valves; ×830.

FIG. 71.—Germinating spore without fungus; ×1040.

PLANT GEOGRAPHY OF NORTH CENTRAL NEW MEXICO[1]

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 160

J. R. WATSON

(WITH SEVEN FIGURES)

The area included in this investigation comprises the northern half of New Mexico, the most detailed study having been made of Bernalillo and portions of the adjoining counties containing a section of the Rio Grande Valley and the Sandia Mountains, but the results have been confirmed by excursions to other portions of the northern half of the territory.

The 35th parallel passes through the region under consideration, which indicates a hot sun during the summer and a warm one during the winter. The altitude ranges from a little less than 5000 ft. in the valley of the Rio Grande to about 11,000 ft. on the northern part of the Sandia Range.

The topography is varied. The recent valley of the Rio Grande, occupying the center of our region, is two or three miles wide. The floor is composed of beds of a hard clay ("adobe"), sand, and gravel. The water level is here usually only a foot or two below the surface and near the river often rises above it, leaving, when the water evaporates, a crust of alkali which whitens the ground like hoar frost on a November morning. The river is a shallow, muddy stream with a fall of five feet per mile. It may be a half-mile or more wide during the June melting of the snow on the Colorado mountains, or entirely dry during August, under the combined influence of drought and the demands of the irrigation ditches above. At low water it exposes extensive mud flats on which a vigorous plant growth quickly develops.

On either side this recent valley is limited by the much dissected edge of the mesa, which rises 100–300 ft. in a mile or two. These hills, although known locally as "sand hills," may be com-

[1] This study was undertaken under the direction of Dr. HENRY C. COWLES.

posed of sand, hard adobe, or a clayey gravel with stones up to the size of a man's head thickly strewn over the surface; or, more usually, all of these deposited in alternate layers, showing plainly its fluviatile origin. On the west side of the valley are occasional sand dunes bearing absolutely no vegetation.

From these hills a clinoplain, known locally as "the mesa" (not a true mesa), slopes gradually upward toward the mountains with a quite uniform grade of nearly 100 ft. to the mile, although appearing to the eye to be nearly level or gently undulating. This mesa is also of stream origin, consisting of the ancient gravels and clays of the Rio Grande intermixed with sand fans and other detritus resulting from the weathering of the mountains. On the east this plain stretches for nine or ten miles to the base of the Sandia Mountains, forming one of those old western river valleys so admirably described by MACDOUGAL.[2] Every two or three miles this mesa is crossed by a sandy "arroyo," or dry stream bed, which once or twice each summer becomes a raging torrent for an hour or two. These arroyos lie in shallow valleys, the largest, however, having banks 100 ft. or more high. Few of these arroyos reach the river proper, but spread their flood waters over the floor of the recent valley, building up fans of an alluvium-like clay at their mouths. Numerous smaller arroyos head on the "mesa" proper or on its dissected edge. A similar mesa on the west side of the valley is partly covered by a flow of lava so recent that it has suffered almost no weathering, the shallow soil that covers it, to the depth of a few inches, having been deposited by the wind. A mile or so back from its edge this lava field is surmounted by five volcanic cones, the largest being about 300 ft. high.

From the eastern mesa the Sandia and Manzano mountains rise rather abruptly, sand and gravel fans at the mouths of the cañons forming a transition. The range is a typical block mountain with the principal fault at its western edge. It is composed of Archean granites and schists, capped by a layer of Carboniferous limestone 50–200 ft. in thickness. This limestone shows a dip to the southeast of about 20°. To the east of the main ridge lie

[2] MACDOUGAL, D. T., Botanical features of North American deserts. 1908.

mountains of less elevation and Permian beds of red clay. Ten miles east of the Sandia Mountains the Ortiz and San Pedro mountains rise to an altitude of 8000 ft., followed by the fertile prairies of the Estancia Valley.

Climate

The most important factor in the climate is aridity. The precipitation at Albuquerque averages 7.43 in. per year; that of the mountains is much greater, but unfortunately has never been measured. Perhaps 20–24 in. would be a fair approximation for the higher parts of the range. The distribution of the rainfall is also an important factor. At Albuquerque the average for ten years was as follows:[3]

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.48	0.33	0.22	0.26	0.69	0.35	1.43	1.07	1.7	0.77	0.46	0.31

It will be noticed that there is a rainy season beginning in July and one of less intensity in May. This is valuable to vegetation, as the bulk of the precipitation comes during the warm season.

It would appear from observation that a precipitation of less than 0.25 in. has no effect on vegetation, with the possible exception of some of the shallow-rooted grasses, as it does not penetrate the thirsty soil to a sufficient depth to reach the roots. On the other hand, much of the summer rain comes down in such a deluge that a goodly percentage runs off the mesa and especially its foothills. The distribution and the amount are both highly variable and materially influence the aspect of the vegetation from year to year. The May rains especially often fail altogether, and it is said that during a recent drought Albuquerque received not a drop of rain for thirteen months.

The distribution of the precipitation in the mountains is radically different. Judging from observation, the summer rains are about 50 per cent in excess of those at Albuquerque. But while snow is rare in the valley, the higher parts of the mountains are covered with it for a considerable part of the winter, and snowstorms frequently occur over the whole of the range and extend down some distance on the mesa. This snow, slowly melting,

[3] MAGNUSSON, C. EDW., Bull. Univ. N.M. no. 5.

thoroughly saturates the soil; much more so than the often torrential rains of the summer which quickly run off. The writer has been surprised to observe how brief an influence these summer rains have on the mountain streams and springs. A day or two after a heavy shower they are nearly as low as before, although they may have poured out a deluge for an hour or two. A heavy winter snow, on the contrary, maintains a steady flow throughout most of the summer.

TEMPERATURE

Because of its altitude and southern latitude, the climate is characterized by a comparatively low mean annual range of temperature and a high daily range. Although the thermometer is known to go to zero or below at night, the mean for January is 34° F. (MAGNUSSON, *loc. cit.*). This is due to the high temperature in the middle of the day (average maximum 46°). For July the mean is 76.4° F., the average maximum 89°,[4] and the average minimum 63.5°. The absolute maximum for the ten years was 104° F., and it has exceeded 100° F. on three different occasions. It is the occasional low temperatures which render it impossible for the larger, thicker cacti and century plants, so characteristic of southern Arizona and Mexico, to grow here. They have been planted repeatedly on the campus of the University of New Mexico, only to perish during the winter.

EVAPORATION FROM A FREE WATER SURFACE

The following data (MAGNUSSON, *loc. cit.*), giving evaporation in inches, show that the ratio of evaporation to rainfall is more than 10 to 1:

Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2.04	2.63	6.17	6.82	10.08	12.63	11.78	10.21	8.00	4.38	1.73	1.4

Total for the year 77.87 inches.

SOIL MOISTURE

Measurements of soil moisture gave the following results: sandy soil in the valley in December (dry season) 0.8 in. below the surface, 30 per cent; sandy soil in the "highlands" (edge of the

[4] A striking characteristic of the arid southwest is the great difference in temperature in the sun and in the shade.

valley), 1.9 per cent; sandy clay on the mesa, 3.9–10 per cent; sandy clay in May on the mesa, 4.8–7.2 per cent.

CAPACITY FOR HOLDING MOISTURE

Some determinations were made to determine the capacity for holding moisture, following the method used by LIVINGSTON,[5] with the following results. In the first column is shown the per cent of water absorbed in proportion to the dry weight of the soil; while in the second column the per cent of water is calculated in terms of "wet volume," that is, the volume of the dirt when allowed to settle under water. There is practically no humus in any of the mesa soil. In the piñon association there is a little humus, in the yellow pine association more, while in the Douglas spruce there is abundant humus.

Open mesa (Gutierrezia association)	23.8 per cent	37.3 per cent
Bigelovia association (edge of mesa) where		
Bigelovia was most luxuriant	21.4	35.4
Hymenatherum society of the association	12.7	25.8

WIND

A factor influencing the evaporation from plants is wind. Although the average velocity is probably not great, autumn and early winter being especially calm, there occur, especially in late winter and spring, violent windstorms which pick up the sand and even pieces of gravel large enough to break the glasses of a man walking against it. These violent winds plants must encounter, and this may be the factor which prevents the growth of lichens on the rocks on the mesa. The prevailing direction of the wind is south and southwest. This seems to be the explanation of the presence of sand dunes on the western edge of the valley and their absence on the eastern side.

LIGHT

In this clear atmosphere the illumination is of course intense and very annoying to the traveler in summer. Concerning the percentage of cloudiness MAGNUSSON presents the following aver-

[5] LIVINGSTON, B. E., Relation of desert plants to soil moisture. BOT. GAZ. **50**: 241–256. 1910.

age for ten years: days entirely clear, 219.4; days partly clear, 104.9; days cloudy, 38.4.

Plant formations and associations

Floristically the country is very interesting, as it is the meeting place of the northern and eastern flora with that of the arid southwest. On the slopes of the mountains the botanist familiar with the flora of the east would be able to recognize at least the genus of nearly every plant encountered, while upon the mesa, with the exception of *Gaura* and *Salsola*, scarcely a genus would be familiar.

RIVER VALLEY FORMATIONS

1. *Cottonwood forest*

Along the Rio Grande, where the water-table is never very far from the surface, there occurs an open and more or less pure forest of *Populus Wislizenii*. The trees are small, due probably to the operations of the native ranchers in their search for fuel and fence posts, for individual trees of this species planted in dooryards are veritable giants in girth. Scattered throughout this forest and especially along the banks of the streams are a few willows, clumps of the shrubs *Baccharis Wrightii* and *Cassia bauhinioides*, while on the ground grow *Juncus balticus*, *Trifolium Rydbergii*, *Aster spinosus*, and a little grass. This forest is monotonously uniform and poor in species.

2. *Juncus-Houttuynia association*

Alternating with the last in its possession of the river banks is a meadow-like association of which *Juncus balticus* and *Houttuynia californica* are the dominant plants. Just what factors determine which of these two associations will take possession of a given area is not clear to the writer. However, it would seem that, given time enough, the cottonwoods will occupy most of the situations. The *Juncus-Houttuynia* association, however, is not a necessary stage in the formation of a cottonwood forest, as the latter may develop directly from a mud bank. Whenever a mud bank is exposed for a few weeks in summer, a vigorous growth at once appears, of which young cottonwoods, willows, cat-tails, and

cockleburs are the dominant species. If one looks closely, many small annuals and numerous specimens of *Riccia fluitans* are seen; but one misses the bulrushes and sedges he would find in similar places in the east. The usual fate of such young growth is to be washed away upon the return of high water, but should this fail to happen for a year or so, the young cottonwoods may be large enough to hold the soil, and a forest develops. Other characteristic plants of this association are *Baccharis Wrightii*, *Helianthus annuus*, *Dysodia papposa*, *Onagra Jamesii*, *Amorpha fruticosa*, and *Rumex Berlandieri*. In more sandy places one meets *Aster spinosus*, *Maurandia Wislizenii*, *Sesuvium sessile*, and *Cycloloma atriplicifolia*.

Much of the valley is under ditch and as a consequence does not show the characteristic vegetation, but along the ditches a dense thicket usually develops, composed of *Cassia*, willows, sunflowers, *Solidago canadensis* var. *arizonica*, and others.

3. *Bigelovia association*

On higher ground, where the water level is deeper, there is found a variety of edaphic plant associations due chiefly to differences in slope and soil and the consequent ability to hold water. But on much of this area the dominant plant is *Chrysothamnus* (*Bigelovia*) *Bigelovii*, a low shrubby perennial, almost leafless, but the green shoots retain their color throughout the year, so that in winter, when the prevailing color of the landscape is brown, this formation may be detected ten miles away. It covers most of the higher gravel beds of the valley and the dissected border of the mesa, but stops abruptly and completely at the edge of the more level mesa. With the exception of the rock surfaces of the mountains, this is the most xerophytic of all our situations; the steep clay hills quickly shed what little water falls on them. In sandy places *Yucca glauca* is fully as abundant as the *Bigelovia*, and in places where a foot or two of sand covers a stratum of adobe, the *Yucca* becomes the dominant plant. In places where the sand is deep and extensive, such as the wider valleys or arroyos, a society, of which *Parosela* (*Dalea*) *scoparia* is the abundant plant, takes possession of the soil, often to the entire exclusion of *Bigelovia*, but not

of *Yucca*. This plant has slender wandlike branches which are regularly winter-killed for several inches. Other plants very abundant here are *Croton texensis*, the spiny ragweed (*Franseria acanthicarpa*), *Orobanche multiflora*, and *Cenchrus tribuloides*.

The steeper hills of this formation are too xerophytic even for *Bigelovia*, and here the low shrubby composite *Hymenatherum acerosum* is the most abundant plant. Associated with it usually are *Crassina* (*Zinnia*) *grandiflora*, *Ephedra trifurca*, whose leafless stems both look and feel like a branched *Equisetum*, and several species of *Eriogonum*. The *Crassina* has a method of seed dispersal that is not mentioned in any text with which I am familiar. The very large ligules of its ray flowers, instead of dropping off, become dry and papery, and when the seeds are ripe, the whole head separates from the stem and goes rolling off over the plain and hills, a diminutive tumbleweed.

The arroyos of this dissected edge of the mesa show an interesting succession of societies, characterized by successively smaller plants as one ascends. If sufficiently large to deposit considerable sand, their lower courses are occupied by the desert willow (*Chilopsis saligna*), a plant with pretty *Catalpa*-like blossoms. Its leaves, however, resemble very closely those of such a willow as *Salix longifolia*. It is the tallest shrub outside of the mountains and the cottonwood forest, reaching a height of 15–20 ft.

Ascending the arroyo this society is replaced by one in which *Fallugia paradoxa* is dominant. This rosaceous plant is very slow to drop its leaves, retaining them until late in the winter. It has pure white blossoms and plumose fruit. It grows to a height of 3–4 ft. in dense thickets, which are even more dense underground, where about half of the stems are found, in which respect it resembles the famous mesquite of more southern regions, the plant which gave rise to the expression that in New Mexico one "climbs for water and digs for wood." Here grow also two low perennial evergreen composites, *Berlandiera lyrata* and *Melampodium cinereum*. After the summer rains there appears here, as on the mesa, a relatively abundant growth of annuals, among which the composites *Hymenopappus flavescens*, *Thelesperma gracile*, and *Baileya multiradiata*, together with *Pentstemon ambiguus*, are characteristic.

A little higher up, where the arroyo is not over 6–8 ft. wide, the bed proper is generally free from plants except an occasional *Euphorbia*, but the banks are occupied by *Bigelovia*. Near its head, where the arroyo is only 1–2 ft. wide, its sides are occupied by a narrow fringe of shrubs, chief of which are *Parosela formosa* and *Lycium pallidum*.

In the valleys of the larger arroyos that continue the mountain streams there appears yet another society, characterized by the dominance of either *Suaeda Moquinii*, or the greasewood *Sarcobatus vermiculatus*, or both, the former being more particularly confined to the adobe fans at the mouths of the arroyos. Like so many of the shrubby plants of this region, these and especially the *Suaeda* catch the wind-blown dust and allow it to accumulate among its stems, making mounds like low sand dunes, but in this case composed of adobe. For this reason this association is covered with hummocks often 6 and sometimes 10 ft. high. This is an alkali society, due to the evaporation of the flood waters of the arroyo, and has the same relation to the arroyos as a floodplain forest to a river valley in the east. Mixed with salt grass it is the dominant association around the salt beds and lakes of the Estancia Valley, as well as along the Rio Salada branch of the Jemez River.

MESA FORMATION

This occupies the more level ground of the mesa proper and stops abruptly at its dissected edge, as stated under the last heading. This was undoubtedly originally a grassland, and is so yet where it has not been too seriously over-grazed. It should probably be classified as a steppe. Now, thanks to lack of scientific control of grazing, it has been so invaded by the composite *Gutierrezia* (a somewhat shrubby perennial that grows to be 3 ft. high, and is often called "goldenrod") as to merit being called a *Gutierrezia* formation (fig. 1). The seasons of 1909 and 1910 were drier than usual until about July 20, and as a result 90 per cent of the plants are entirely dead and most of the remainder show only a small branch or two alive. In the autumn of 1907, after an unusually wet (or less dry) season, the entire mesa was a sea of gold, but during those two years it bloomed only in the mountains and

along trails where there is less crowding and where the dust of the trail conserves the moisture after the principle of dry-farming. In 1911 the summer rains commenced in late June and the plants that survived are thrifty and show abundant bloom.

The mesa is monotonously uniform, especially in winter when one may ride for miles and see only a few grasses, *Gutierrezia*, clumps of *Opuntia fragilis*, or occasionally a *Yucca glauca* or a prickly pear (*Opuntia* sp.).

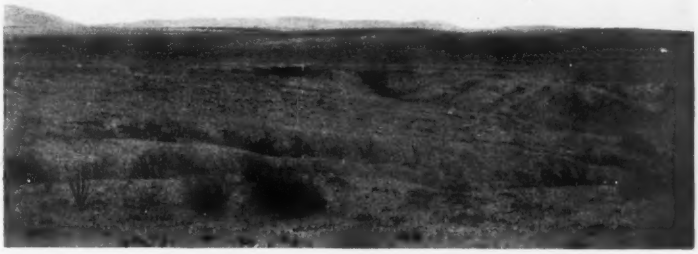

FIG. 1.—The head of an arroyo on the edge of the mesa: in the foreground, *Gutierrezia*, *Salsola*, and *Yucca glauca;* to the extreme left a clump of *Chrysothamnus Bigelovii;* in the distance the *Gutierrezia* association.

The plants of the mesa belong to three ecological groups. (1) Plants like the cacti, *Bigelovia*, *Yucca*, *Sarcobatus*, and *Suaeda*, which have large, usually underground stems or roots, in which moisture is accumulated. (2) Annuals and perennials with underground stems, including by far the largest number of individuals, but usually not the largest and most conspicuous. They are plants which are able to wait for the rains and then to make an exceedingly rapid growth and maturity. Here belong most of the mesa herbs and grasses. The latter cure perfectly *in situ* and make most excellent hay. It is this property of the grasses that makes the grazing industry possible in this country. (3) The third class includes a few plants that are winter annuals. The

fall rains and the occasional snow flurries during the winter afford them sufficient water for growth in favorable situations, and they are ready to blossom with the spring rains. The most conspicuous examples in this class are *Phacelia corrugata*, some of the loco weeds (*Astragulus* sp.), *Draba*, *Gilia*, and sometimes *Gaura coccinea*, *Sideranthus spinulosus*, and many of the plants that are ordinarily summer annuals may occasionally develop during the winter and blossom with the first shower of spring or summer. Indeed, the one feature of the vegetation of this region that attracts the attention of one accustomed to more humid regions is the absence of seasonal periodicity on the part of most of the herbs and many of the shrubs. With regard to relatively few species can one speak of spring, summer, and autumn flowers here. They grow and blossom when the rains come, be that March or August. During 1909 and 1910 the rains came July 20 and July 23 respectively, and the result was that the mesa was brown and lifeless until then, but by August 1 it was a garden, nearly covered by a mat of vegetation, made up of grasses, *Abronia*, *Allionia*, *Townsendia strigosa*, *Houstonia humifusa*, *Plantago Purshii*, *Asclepias brachystephana*, *Wedelia incarnata*, Russian thistle, and *Solanum elaeagnifolium*. By September 10 all was over and the mesa had assumed its usual brown hue. Thus in six weeks the annuals and the underground perennials had grown, flowered, and matured their seeds. The exceptions to this rule are those plants in the first class, the larger shrubs, the cacti, yuccas, and other plants having thick roots or stems providing for the storage of water. With May come the blossoms of the stemless evening primroses (*Oenothera* sp.), the chimaja (*Cymopterus*), and the wild onions. When June arrives, we have the flowers of the cacti, yuccas, and the desert willow; while September brings out the blossoms of *Bigelovia* and October the *Gutierrezia*, if there has been rain. This formation and the next two are classed as Upper Sonoran by MERRIAM and his followers.

In the middle of the mesa, 15 miles to the south, the outcropping of a layer of sandstone causes a succession of springs to appear, and about these springs are cottonwoods, *Juncus*, *Houttuynia*, and other plants of the valley. In other words, a spring changes Upper

Sonoran to Lower at once. On the other hand, there appears on the rock cedars and other plants characteristic of the next formation. This association is also spread over the mesa west of the river and over the lava field where the species are identical with those of the sandy clay of the mesa, but some, especially *Gutierrezia*, are stunted. Here also are a few cedars, *Rhus*, and other mountain plants. This lava field seems to receive slightly more rainfall.

As one approaches the mountains and ascends one of the sand or gravel fans at the mouths of the cañons, a new plant appears,

FIG. 2.—At the base of the Sandia Mountains: *Opuntia arborescens* society; *Rhus trifoliata* appears in the center, and in the background on the rocky slope are black looking clumps of *Nolina*.

Opuntia arborescens, whose cylindrical stems, 6–8 ft. tall, bear beautiful deep rose blossoms in June, and yellow fruit the remainder of the year (figs. 2 and 3). These cacti form dense thickets, which with *Yucca glauca*, *Croton texensis*, and *Fallugia*, which again become abundant here, are quite as characteristic features of these fans as the more abundant *Gutierrezia* and grasses.

CEDAR FORMATION

Next comes the formation of which *Juniperus monosperma* is the dominant plant. East of Albuquerque it is confined strictly

to the mountains, but where the mesa rises higher (6500 ft. or over) it stretches out over the plains. In the Estancia Valley it seems to be spreading at the expense of the prairie, as considerable areas are dotted over with young trees where there are no signs of old ones. But in many places, as here, it clings to the rock outcrop and to the neighborhood of scattered rocks, doubtless because of the moisture conserved under them. In this connection it is

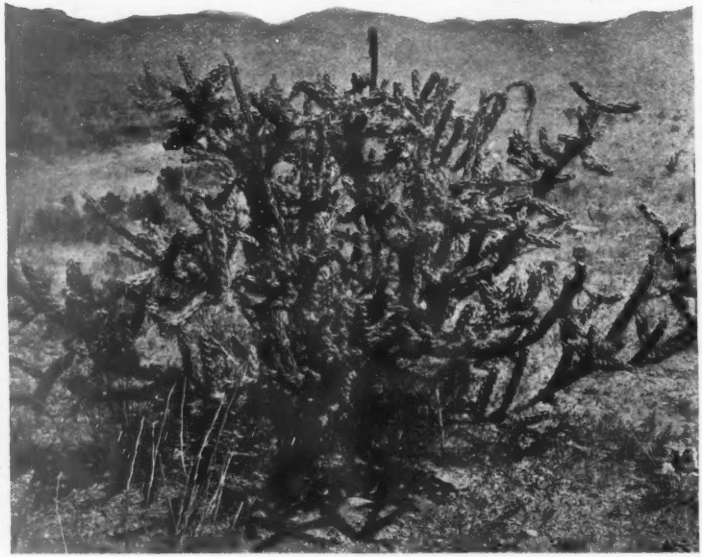

FIG. 3.—*Opuntia arborescens* in fruit: to the left is an arroyo

interesting to recall the occasional occurrence of cedars on the lava a thousand feet lower. That the lower edge of this formation is limited by the supply of soil moisture is evident. On the whole, it coincides quite closely with the lower limit of the usual winter snow. Near the lower edge, especially, the trees are far apart, broken, stunted, gnarled, constantly recalling an old neglected orchard in a back pasture in Ohio. *Gutierrezia* and *Yucca glauca* extend into this formation and *Opuntia arborescens* is abundant

and characteristic. Other members are *Rhus trilobata*, *Nolina texana* (a long-leaved liliaceous evergreen), and the spiny-leaved oak, *Quercus undulatus*. The *Rhus* is also imperfectly evergreen, and indeed there is less difference between the winter and the summer aspect of this formation than of any other, because there is less difference in the relative humidity of the soil.[6]

PIÑON FORMATION

This has been combined with the last by MERRIAM and other writers, and they do shade into each other very gradually, even imperceptibly, but no more so than do the *Pinus ponderosa* and Douglas spruce formations, which are separated by these authors. Furthermore, the piñon (*Pinus edulis*) never extends as far down the mountain side as does the cedar, the differences being on the average at least 500 ft. Other plants very characteristic here are *Yucca baccata* or "amole," mountain mahogany (*Cercocarpus parvifolius*), *Philadelphus microphyllus*, *Lesquerella Engelmanni*, and *Tragia nepetaefolia*.

YELLOW PINE ASSOCIATION

This is the "transition zone" of MERRIAM, which he states is on the whole more closely related to the Sonoran than to the Boreal, a conclusion which seems to the writer to be incorrect at least so far as plants and insects are concerned. The latter are treated in another publication.[7] The characteristic plants, after the *Pinus ponderosa scopulorum*, are *Geranium atropurpureum*, white oaks, red cedar (*Juniperus scopulorum*), the pasque flower (*Anemone patens Nuttalliana*), wild gooseberry (*Ribes divaricatum irriguum*), *Ptelea mollis*, wild grape (*Vitis arizonica*), cudweed (*Antennaria plantaginifolia*), and New Jersey tea (*Ceanothus Fendleri*). Here occurs a sharp and complete change of flora. There is much more difference between this formation (fig. 4) and the mesa or even the piñon formation less than a mile away, than there is between it and the woods of Ohio, as witness the preceding genera, if not species.

[6] Whether the oaks and *Rhus* drop their leaves early in the winter or carry them until spring is determined by the soil moisture. In less dry winters and along arroyos they retain them. Under more xerophytic circumstances the leaves are dropped.

[7] Report of the N.M. Resource and Conservation Commission. December 1911.

Here is a most interesting tension line between the flora of the arid southwest and the more humid north.

The association descends in some places to 7000 ft., and extends to the top of the range at 10,000 ft., and coincides very closely with the region of deep winter snow. On the western slope its aspect is somewhat different from that of the eastern slope. On the

FIG. 4.—View toward the south in the Sandia Mountains (about 8500 ft.) in the yellow pine association: in the foreground the oak chaparral (*Quercus* sp. and *Robinia neo-mexicana*) and yellow pine, and to left of center a Douglas spruce; in the distance, covering a north-facing slope, is the Douglas spruce association.

former it reaches its best development in amphitheater-like U-shaped valleys, which collect the winter snow and practically protect the trees from the drying winds and sun of summer. These areas I have called "pine parks." On the east slope, with its greater precipitation, the forests are more extensive and possess a flora which reminds one very forcibly of that of the pine forests of Kentucky, especially where there has been a fire. The dominant

grasses here, as there, are species of *Andropogon*, and mixed with them are *Liatris punctata*, *Ratibida columnaris pulcherrima*, and *Zygadenus*.

In places along streams charged with lime the red cedar often takes almost entire possession of the soil, forming a quite distinct association.

FIG. 5.—Top of Sandia Mountains: white oaks occupying a depression where they are sheltered from wind.

In the Sandia Mountains the white oaks are very characteristic of this formation, but in the more mesophytic Jemez Mountains, and also on Mt. Taylor, where the yellow pine grows even more luxuriantly, there is much less oak, and MERRIAM states that none was seen on the San Francisco Mountains, although COWLES reports its occurrence upon the southern slopes. The explanation of this varying amount of pine and oak is to be found in the fact that the oak is able to grow in more xerophytic situations than the pine (fig. 5). It, with *Robinia neo-mexicana* and bearberry

(*Symphoricarpus rotundifolius*), forms a dense and almost impenetrable chaparral 4–5 ft. high, which covers the highest, steepest slopes, and the wind-swept and therefore xerophytic mountain tops. In these parts of the range there is very little pine or spruce, except on north-facing slopes, and from a study of the Sandia Mountains alone one would be tempted to place the oaks in a separate formation; but there are clumps of oak among the pine in all situations, and the study of other ranges would seem to indicate that they belong to the same formation but that the oaks form a more xerophytic association in this formation. Furthermore, both the oaks and the locusts reach their maximum size only in the more mesophytic places among the pines and spruces.

The herbs of this association are also somewhat different. Conspicuous are several species of *Pentstemon*, *Campanula rotundifolia*, *Ceanothus Fendleri*, *Thalictrum Fendleri*, and somewhat less common are *Hedeoma Drummondii*, *Gentiana affinis*, and *Calochortus Gunnisonii*.

In the Manzano Mountains the alligator juniper is common in what is chiefly the *Pinus-Andropogon* association, but having some elements of the piñon formation. This would seem to be about the northern limit of *Juniperus pachyphloea*, as it is entirely absent from the Sandia Mountains.

Mountain meadows

In places (usually saddles) on the top of the range, the chaparral gives place to a meadow-like growth, composed, however, not chiefly of grasses, but of low herbs, *Potentilla*, *Castilleja*, *Brickellia*, *Chrysopsis villosa*, *Aphanostephus humilis*, *Gymnolomia multiflora*, *Actinella acaulis*, *Achillea lanosa*, *Oxytropis Lamberti*, *Allium stellatum*, and cacti of the genera *Mamillaria*, *Cereus*, and *Echinocactus*.

These open places are small, the largest being about a half-mile long, and they occupy the less xerophytic situations. They are sufficiently numerous to enable one to walk with comparative ease along the summit of the range, dodging from one to another and thus avoiding most of the chaparral.

DOUGLAS SPRUCE FORMATION

Covering north-facing slopes above 8000 ft. and extending down the narrower cañons to about 7000 ft., we have a formation of which the Douglas spruce (*Pseudotsuga taxifolia*) is the dominant tree (fig. 6). This is the most mesophytic and dense of all our forests. Here occur the blue and Canada violets, *Berberis aquifolium* (*repens*), *Galium* sp., *Monarda fistulosa*, *Mertensia oblongi-*

FIG. 6.—In the cañon the Douglas spruce association; on the rocky slope the *Pinus ponderosa* association; in the foreground, white oaks, verbena (in bloom), and mountain mahogany; a small red cedar to the right of the rocks in the center.

folia, *Polemonium foliosissimum*, *Pachystima myrsinites*, *Oxalis violacea*, *Prunus demissa*, *Fragaria*, *Rosa arkansana*, *Amelanchier alnifolia*, *Heuchera parvifolia*, *Sedum Wrightii*, *Corydalis aurea*, *Clematis* (*alpina*) *occidentalis*, *Aquilegia canadensis*, *Stellaria Jamesii*, and *Smilacina stellata*. This is the "Canadian zone" of MERRIAM, but nowhere in this locality does it make a complete belt around the mountains. It occurs in its full development only in the most mesophytic places, as in the narrower V-shaped cañons and on north-facing slopes where snow accumulates in huge drifts

during the winter, but scattering trees, dwarfed and stunted, rise from the chaparral over most of the summits of the range mixed with the yellow pine, especially at lower levels, and with the blue spruce (*Abies concolor*) at higher. On North Sandia Mountain, which, on account of its greater elevation and perhaps more east and west trend, has a higher precipitation, the latter tree forms almost pure forests. On the ground in its shade is a luxuriant and in places an almost pure growth of *Goodyera Menziesii*.

FIG. 7.—Top of North Sandia Mountain: *Picea Engelmannii;* in the foreground, *Potentilla*, *Castilleja*, and *Aphanostephus*.

On the very highest and most exposed part of North Mountain the first are replaced by Engelmann's spruce (fig. 7). This would place it in MERRIAM'S "Hudsonian zone," and it is so mapped. On these heights one meets an occasional *Pinus flexilis*.

CAÑON ASSOCIATIONS

Ascending a cañon a very interesting succession of associations presents itself. The first tree met approaching the mountains from one of the arroyos is the hackberry (*Celtis reticulata*), usually only a few scattered trees or a clump here and there. Next comes

a society dominated by box-elders, also rather scattered, and with considerable grape (*Vitis arizonica*). These seem to be the cañon representatives of the cedar and piñon formations respectively.

Higher up and in the narrower, more mesophytic portions of the cañon there occurs a society dominated by *Populus angustifolia*. This corresponds with the pine formation on the whole, and if the cañon is open or U-shaped, the yellow pine will occupy the floor with the poplar along the stream. Ascending still higher, where the cañon becomes decidedly V-shaped, the Douglas spruce formation holds full sway. And as one nears the head, above the permanent stream there usually occurs an association of quaking aspens, somewhat less mesophytic than the Douglas spruce formation. In the shade of the aspens grow *Rubus deliciosus*, *Osmorrhiza nuda*, *Saxifraga bronchialis*, *Jamesia americana*, *Delphinium scopulorum*, *Actaea spicata*, *Pedicularis procera*, *Frasera speciosa*, and nearly always young spruces. After a fire in the Douglas spruce the quaking aspen always takes possession, but it has also its natural place as a transition between the oak chaparral and the Douglas spruce in the biotic succession.

The biotic succession in the Sandia Mountains is as follows: the bare rock first incrusted with crustose lichens, then foliose lichens, mosses, herbs, oaks, followed in some cases directly by Douglas spruce and in others by aspen and then the spruce; and then as physiographic succession comes in, the poplars, pines, and box-elders in the cañon; and pine, piñon, and cedar on the slopes, until the ultimate formation of the mesa is reached.[8]

Response to climatic factors

This complex of associations is of course due to a complex of causes, of which the most important are relative humidity of the air and more especially that of the soil, and not the average temperature of the growing or any other season, as some eminent authorities have maintained. Temperature, of course, is a factor, but principally as it affects the humidity. I have mentioned the inability to grow certain cacti because of the winter's cold. There

[8] A study of Mt. Taylor indicates that the alligator juniper has a place between the yellow pine and the piñon.

are narrow cañons in the lower parts of the mountains which would doubtless be occupied by Douglas spruce were they situated at a greater elevation, chiefly because of the greater precipitation. On the other hand, most of the trees of the mountains are growing on the campus of the University of New Mexico at an elevation of only 5200 ft., but they are carefully irrigated, and the Douglas spruces are in the shade of cottonwoods. The storksbill (*Erodium cicutarium*) grows in the mountain cañons and at an elevation of 5000 ft. in the valley. In the former situations it is in blossom nearly all winter, often directly beside a snowbank, and doubtless because of the snowbank, while those in the valley do not bloom until the May or July rains.

Fallugia paradoxa is a most interesting plant in this regard. As mentioned above, it is a very characteristic plant in the arroyos of the mesa and its edge down to less than 5000 ft. It grows at a lower altitude than this farther south, and doubtless would here were there lower altitudes. Now these arroyos are the hottest places in this region. Their sands reflect the desert sun's glare and the banks obstruct the breeze. Yet this same *Fallugia* forms thickets on the Sandia Mountains at an elevation of over 9000 ft. on steep slopes facing the southwest, and it grows at all altitudes between. On a basis of temperature control, this distribution seems inexplicable. But these arroyos are the least xerophytic places on the mesa. The soil at the depth of a foot or two is always moist, due to the fact that the arroyo brings down a flood of water two or three times each summer and the sand conserves this and the rain most thoroughly. On the contrary, those steep southwestern slopes are the most xerophytic places in the mountains, with the exception of course of bare rock. But on account of greater rainfall, these most xerophytic places of the mountains are about as moist as the least xerophytic places on the mesa, and *Fallugia paradoxa* occupies both situations.

On an ascent of the mountains made on May 8, 1910, the oaks in the lower parts of the cañons were found in full leaf, and their blossoms gone; a little higher they were just leaving out and blossoming; at the top of the range not a bud had started. Again, on October 6 the leaves were still green and vigorous at the base,

but on the summit brown and frost-killed. Thus it is seen that the growing season is at least a month shorter on the summit, but the same oaks grow in both situations.

Another illustration of the influences of moisture is seen along the Jemez River. This fair-sized stream comes roaring down off the Jemez Plateau through a rather shallow cañon which faces the south. This (altitude 6000–7000 ft.) is occupied by the Douglas spruce formation, but the slopes on each side are occupied by piñon, the yellow pine being largely omitted. The branches of the spruce and piñon are in places at the same level and subject to the same hot sun and consequently the same temperature, but the roots of the Douglas spruces have access to the unfailing water supply of the stream.

This tendency of the "Canadian zone" to creep down the cañons and of the Sonoran to ascend the ridges is noted by MERRIAM, but is explained as due to warm and cool winds, vertical exposure to the sun, etc. It receives a much simpler explanation in that the ridges are more xerophytic than the cañons. At night, when a plant is supposed to make a goodly share of its growth, these ridges are little if any warmer than the adjacent cañons. They are subject to greater and more sudden changes of temperature, to drying winds, and are less able to hold their moisture—*they are more xerophytic.*[9]

In most situations in the Sandia Mountains the oaks of the transition zone entirely surround the colonies of the Douglas spruce (Canadian zone). In watching the Sandia Mountains during four winters I have been struck by the very close correlation between the lower limit of the average winter heavy snow and that of the lower limit of the yellow pine. I believe that it is chiefly these snows that determine the distribution of this tree. Far be it from me to maintain that the temperature has no effect on the plants of this region. I am simply contending that in this arid region, at least, water is more important. Any scheme for mapping "life zones" should be based on all the factors determining the same and not on one alone.

[9] This same tendency is seen in the Rio Grande Valley, where occur many eastern and northern genera and even species (as *Aster*, *Solidago*, *Cassia*, etc.) which are absent from the higher but drier mesa.

Light also is of course a factor even with the plants of the mesa. I tried to grow some *Yucca* and *Fallugia* in the slight shade of some box-elder trees, but they all died. It is probable that light is quite as important indirectly through its acceleration of transpiration as directly through its relation to photosynthesis.

Furthermore, these different factors may be of a very diverse importance in different groups. What may be an effective barrier for one form of life may have little influence on others. The sum total of heat during the season of reproduction may well be more of a barrier to mammals than to plants. BANKS has remarked in a recent publication that it would seem to be necessary to have a different arrangement of zones for at least every family of insects.

Summary

1. In North Central New Mexico the arid climate of the southwest meets (in the mountains) the more humid one of the north and east.

2. Corresponding with this abrupt change of climate there is an abrupt change of plant life.

3. The genera and some of the species of the mountains are identical with those of the east; those of the mesa are entirely different. There is a greater difference between the flora of the yellow pine association and that of the mesa, less than a mile away, than between the former and Ohio and probably even Europe or Japan.

4. The chief factor determining this change is moisture, the supply of which is largely determined by precipitation, ability to hold it, and protection from drying winds and sun, as shown by the following facts:

a) The same plants (*Fallugia*, *Erodium*, oaks) occur throughout a great range of altitude and temperature, but in soil of about the same degree of humidity.

b) Spruces and piñons will grow with their branches almost touching if the roots of the former have access to an unfailing water supply.

c) A spring will change "Upper Sonoran" to "Lower Sonoran."

d) Plants as *Erodium* or *Draba* bloom much earlier in the cooler but moister mountains than on the warm but arid plain.

e) A patch of mesophytic spruces ("Canadian zone") is very frequently entirely surrounded by the more xerophytic oaks of the "Transition zone."

f) The tendency of the higher zones to creep down the cañons and of the lower zones to creep up the ridges receives a much more plausible explanation in connection with the supply of moisture in the two situations, than through the cooling effects of descending currents and the warming effects of ascending ones.

5. An arrangement of "zones" should be based on all factors determining the distribution of life and not on one only, especially in a region where that one is of secondary importance.

6. Most of the plants of the mesa do not show the marked seasonal periodicity of the east.

7. Plants having large organs for the storage of moisture do show seasonal periodicity.

8. A characteristic of much of the vegetation is the ability to lie dormant until the rains come, and then to make an exceedingly rapid growth and reproduction.

9. The differences in amount and distribution of rainfall in different years causes a more marked response in plants (shown by height and reproductive activities) than in more humid regions.

10. The region is a particularly good one in which to study physiographic plant ecology because of the abrupt differences in physiography and climate.

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THE PERFECT STAGE OF ACTINONEMA ROSAE[1]

FREDERICK A. WOLF

(WITH PLATE XIII)

Perhaps no plant disease has been more widely observed or is more generally known, both in Europe and the United States, than the black spot of roses caused by the parasitic fungus *Actinonema rosae* (Lib.) Fries. The spots, which are more or less circular in outline, are characterized by a very irregular, fibrillose border. This fibrillose character is due to the radiating strands of mycelium which occur beneath the cuticle. Appearing among the mycelial strands are numerous dark specks, the fruit bodies of the fungus. The spots may be isolated and confluent, or so numerous as to involve the entire upper surface of the leaf. Plants which are attacked become defoliated early in the season, and the leaf buds, which should remain dormant till the next year, often open late in the season. As a result, the plant is weakened so that it blossoms poorly or not at all in the following season.

Since very little is known concerning the life history of the fungus and the development of the *Actinonema* stage, an attempt has been made by cultures on artificial media and on the host to furnish a more satisfactory knowledge of this interesting organism. Before giving an account of this study it may be well to state briefly the characters of the vegetative and fruiting structures of the rose *Actinonema*.

The vegetative body of the fungus consists of two parts, the subcuticular mycelium and the internal mycelium. The subcuticular mycelium is immediately underneath the cuticle, being above the outer wall of the epidermal cells. It consists of branched, radiating strands of mycelium which anastomose, making a network. Each strand consists of several filaments united together, either side by side or sometimes superimposed. At the right of the acervulus in fig. 1 is shown a cross-section of one of these strands. The internal mycelium penetrates the mesophyll of the

[1] Contribution from the Department of Botany, Cornell University. No. 143.

leaf and furnishes nutriment for the subcuticular part. It is connected with the latter by occasional hyphae which penetrate the epidermal cells or pass between them.

A section of the fruit bodies or acervuli perpendicular to the surface of the leaf shows that they are formed between the cuticle and the outer wall of the epidermal cells. They are consequently flattened. The stroma of the acervulus is seated directly on the epidermal cells and consists of a very thin layer of small, hyaline to yellowish, pseudoparenchymatous cells. It is connected with the internal mycelium below by hyphae which extend either through or between the epidermal cells into the mesophyll. Laterally the stroma is connected with the subcuticular mycelium. There is no wall or membrane of fungous tissue covering the acervulus. On the upper side of this stroma certain cells are formed which bear the conidia. These conidiophores are not prominently differentiated in form from the other stromatic cells, but are slightly elongated upward. The conidia are hyaline, 2-celled, and oval to elliptical in outline. They are usually somewhat constricted at the septum. The conidia are formed on the somewhat pointed upper ends of the conidiophore layer. The great numbers which are produced cause such a pressure that the cuticle is finally ruptured. The cuticle, which is the only covering for the acervulus, is thus thrown back irregularly, exposing the mass of conidia and permitting their escape.

While the spots together with the mycelial strands and acervuli appear dark, this color is not due to the fungus, which is almost colorless, but to the disintegration of the cells below the spot.

Development of acervuli

It is from the subcuticular mycelium that the acervuli arise. At certain definite points the mycelium begins to form a stroma, which increases in a centrifugal manner, forming a more or less circular stromatic layer. Certain cells of this stroma which are to give rise to the conidia are directed upward as short stalks. These increase in size, forming a closely aggregated layer standing perpendicular to the stroma. Meanwhile, the mesophyll tissue directly below the acervulus is being disintegrated and a dense

tangle of fungous filaments is formed in its place. From the perpendicular cells arising from the stroma a cell is cut off by a transverse septum. This cell enlarges into an oval body, the conidium, which soon becomes septate. As the conidia are increasing in size, the pressure on the cuticle above becomes greater and greater, so that it is at length broken, leaving the margin of the exposed acervulus irregularly torn (fig. 1). Sometimes a central papilla is present which marks the place where the cuticle will rupture. At maturity the conidia are oval to elliptical and 2-celled. They are hyaline and 18–25×5–6 μ. They may be unequally septate, either straight or subfalcate, and often so deeply constricted at the line of septation that the halves fall apart readily. Several large granules and guttulae are normally present (fig. 3).

Germination of conidia

The conidia germinate within 24 hours in bean agar or in hanging drops of water. Each of the cells may first enlarge, becoming more or less spherical and vacuolate before the formation of the germ tube. Frequently only one of the cells germinates by the formation of one or two germ tubes (fig. 3). No formation of colonies was secured in poured plates of bean agar, although the fungus grows slowly when the conidia are planted on the surface, forming a small, prostrate, tawny colony. Apparently growth ceases as soon as the reserve food material within the conidium has been utilized in the development of the short hypha. This seems to occur when the hypha is 10–20 times the length of the conidium and may have become branched with several septa. If such conidia are cut out with as little of the surrounding medium as possible and transferred to bean pods, using ordinary sanitary precautions, and if the medium is spread out so as to bring the germinating conidium in contact with the pod, further growth may be induced. In two or three weeks small colonies are formed. At first the mycelium is whitish, changing to a pinkish color and becoming pale brown to blackish with age. The colonies do not spread out on bean pods, but form knots of fungous tissue often one-half as high as the diameter of the colony. The tissue of the bean which is attacked becomes blackened in a fibrillose manner,

simulating the blotch on the leaves. Conidia are formed readily on the ends of the hyphae. Such conidia are often so strongly constricted at the septum that each cell is round. There is, then, little surface of contact between the cells and they are readily separable one from the other. These spherical halves germinate in the normal manner (fig. 2). Acervuli apparently like those on the leaves are also formed on bean pods in the blackened areas. These bear conidia like the typical ones from rose leaves.

Systematic position of the conidial stage

The genus *Actinonema* is usually placed by systematists in the Sphaeroidaceae.[2] This family is a group of imperfect fungi possessing a pycnidium of the type present in *Ascochyta*, *Sphaeropsis*, etc. The pycnidium or conceptacle is more or less oval in form, with a membranaceous wall of fungous tissue, usually opening at the apex by a minute pore. Some writers speak of the fruit bodies of *Actinonema* as pycnidia[3] or perithecia.[4] FRANK[5] considered them as very flat spermagonia ("des sehr flachen Spermagoniums"). SORAUER[6] speaks of them as small astomate pycnidia ("die kleinen mündungslosen Pykniden").

It is very evident from the foregoing account that the conidial stage of the rose *Actinonema* is not of the type in which the conidia are borne in a pycnidium or perithecium. The conidia are borne in an acervulus resembling that found in the Melanconiales, as exampled by *Gloeosporium*, *Marsonia*, etc. SCRIBNER[7] has correctly figured the structure of the acervulus and says that while the fungus from analogy is placed with the sphaeriaceous fungi, no perithecia-like or pycnidial structures have been observed.

Partly because of the different interpretations of the morphology

[2] SACCARDO, P. A., Syll. Fung. 3:408. 1884; also LINDAU, G., Sphaeropsidales in ENGLER and PRANTL's Pflanzfam. 1:369. 1900.

[3] LINDAU, G., *loc. cit.*

[4] MASSEE, G., Diseases of cultivated plants. 428. 1910.

[5] FRANK, A. B., Die Krankheiten der Pflanzen. 621. 1880.

[6] SORAUER, PAUL, Handbuch der Pflanzenkrankheiten. 406. 1908.

[7] SCRIBNER, F. L., The black spot on rose leaves. Rept. U.S. Dept. Agric. 366–369. *pls. 8, 9.* (1887) 1888.

of this fungus it has been variously named by different workers. In 1849 the name *Actinonema rosae* (Lib.) Fr.[8] was employed. In 1853 BONORDEN[9] described it as *Dicoccum rosae*, one of the Hyphomycetes. He says that the fungus forms small, closely aggregated pustules of a brown green color which dehisce irregularly. From collections made in 1888–1889, BRIOSI and CAVARA distributed the species under the name *Marsonia rosae* (Bon.) Br. & Cav.[10] because they recognized the acervulus type of fruit body which is characteristic of the Melanconiales. The 2-celled hyaline conidia suggested its position in the genus *Marsonia*.[11] I have been able to examine the specimens distributed by BRIOSI and CAVARA and have found them to be the same as the rose *Actinonema* in the United States. The drawing of acervulus and spores which accompany the specimens show the same structure.[12]

SACCARDO[13] notes that *Marsonia rosae* (Bon.) Br. and Cav. resembles *Actinonema rosae* (Lib.) Fr. This same fungus was described by TRAIL[14] in 1889 as occurring on roses in Scotland. He called it *Marsonia rosae*.

The characters of the genus *Actinonema* have changed from time to time since the genus was established by PERSOON.[15] He applied the name to those forms on leaves and stems having radiate sterile mycelial strands. He describes two species, *A. crataegi* and *A. caulincola*, in neither of which perithecia or conidia were observed.

In 1828, FRIES[16] included two species in the genus *Actinonema*,

[8] FRIES, ELIAS, Summa veg. Scand. 424. 1849.

[9] BONORDEN, H. F., Beiträge zur Mykologie. Bot. Zeit. 282. *pl. 7. fig. 2.* 1853.

[10] BRIOSI and CAVARA, Funghi parassiti delle coltivate od utile. n. 97. 1889.

[11] La natura degli acervuli fruitifera, subcutanei ed erompenti, ci induce a riferire questo funghetto ai Melanconiei sezione delle Didymosporee Sacc. ove trova riscontro nel genere *Marsonia* pure a spore didime e jaline.

[12] Type material was received through the courtesy of the Bureau of Plant Industry, U.S. Dept. Agric. I am greatly indebted to Miss ETHEL C. FIELD of the same Bureau for some notes on the specimens. She finds that there is no apparent difference between *Marsonia rosae* of this collection and other European material which is labeled *Actinonema rosae*.

[13] SACCARDO, P. A., Syll. Fung. **10**:477. 1892.

[14] TRAIL, J. W. H., Micromycetes of Inveraray. 46. 1889.

[15] PERSOON, C. H., Mycologia Europaea **1**:51–52. 1822.

[16] FRIES, ELIAS, Elenchus Fungorum. 151. 1828.

A. padi and *A. crataegi*, the latter showing at length perithecia-like structures, but no conidia were observed. In 1829[17] he employed the name *Actinonema* for the sterile state of fungi belonging to the Pyrenomycetes and Perisporiaceae. Later[18] he characterized the genus as having a fibrillose, radiating mycelium, a delicate perithecium, and bilocular spores, and lists *A. rosae* as one of the species which often possesses only a sterile mycelium. SACCARDO[19] employs these characters as given by FRIES and notes that the fruits have not been observed in many species. Of the 18 species of *Actinonema* which have been described, there are 8 species in which the spores were not observed at that time. The radiating fibrillose character of the mycelium has been used as the principal generic character for these species, thus employing the distinctive character as originally given by PERSOON. LINDAU[20] includes in *Actinonema* astomate pycnidial forms occurring on leaves. The pycnidia arise from radiately actinic strands of mycelium.

The genus *Marsonia* is characterized by having a *subepidermal* acervulus, in which are produced hyaline, 2-celled conidia, very similar to the conidia of *Actinonema*. Several species of *Marsonia* have been described, however, in which the acervulus is *subcutaneous*, as *Marsonia baptisiae* E. & E., *M. panatoniana* Berl., and *M. fructigena* (Rick.) Berl. BRIOSI and CAVARA recognized the true morphology of the rose *Actinonema* acervulus, but attached no significance to the fact that it was *subcuticular* and not *subepidermal*. The *Actinonema*-like character of the mycelium was not taken into account by them as indicative of generic position. TRAIL must have been of the same opinion when he named this same fungus *Marsonia rosae*.

Even though the subepidermal acervulus has been made one of the generic characters of *Marsonia*, it would seem that these subcuticular forms might properly be placed in this genus. On the other hand, we do not know the structure of the perithecia or pycnidia of other species of *Actinonema*. If we accept PERSOON'S

[17] FRIES, ELIAS, Systema Mycologicum **3**:266. 1829.

[18] ———, Summa veg. Scand. 424. 1849.

[19] SACCARDO, P. A., Syll. Fung. **3**:408. 1884.

[20] LINDAU, G., ENGLER and PRANTL'S Pflanzfam. **1**:399. 1899.

characterization of the genus, it has no fruit bodies, but consists only of sterile mycelium.

The rose fungus evidently, then, does not possess the characters of a typical *Marsonia*, nor does it agree with the original characterization of *Actinonema*. Whether these differences are worthy of good generic rank, separating it from both these genera, is a matter for consideration.

Development of the ascigerous stage

During the autumn of 1910, leaves attacked by the conidial stage were collected and placed in wire cages to winter out of doors. When some of these leaves were brought to the laboratory early in April and examined, shield-shaped structures suggestive of the perithecia of the Microthyriaceae were found to be present. At this time, however, no spores had been developed. Fig. 2 shows one of these perithecia as seen in surface view. Such preparations were made by stripping off the epidermis of the leaf together with the perithecia. By April 27 these perithecia had matured and were found to possess characters similar to the genus *Asterella*, a genus apparently including heterogeneous elements.

For the study of the development of the perithecia, material was killed in Merkel's fluid and stained with Flemming's triple stain. By killing material at different times during a period of three weeks, many of the developmental stages were obtained. Not all perithecia on the same leaf are in the same stage of development at the same time. Unfortunately the material was too far advanced for the study of fertilization and the immediate subsequent development. This in itself would be a very interesting study, since nothing is known of these phenomena in the Microthyriaceae.

The shield was found to be entirely separate in origin from the tissue which gives rise to the asci. It is formed immediately beneath the cuticle from the radiating strands of mycelium which now are thick-walled and dark brown in color. The strands themselves can be traced across the shield (fig. 4), showing that the growth begins at any point on the mycelial strand and new cells are added in a centrifugal manner. In this way a more or

less circular shield is formed, the elements of which are arranged in a radiating manner, especially noticeable at the margin of the shield. The cells which make up the shield possess thick, dark walls.

The shield varies in diameter from 100 to 250 μ, and may be more than one cell in thickness. In fig. 6 is shown a young stage in the development of a perithecium. The shield forms a thin layer above the epidermal cells or beneath the elevated cuticle. Beneath the epidermal cells, and above the palisade parenchyma, is an undifferentiated layer of fungous tissue, the stroma from which the asci later arise. This stroma is 3–6 cells in thickness and is made up of cells similar to those of the shield. Occasional filaments connect these two layers through the epidermal cells of the host. In fig. 7, when the fertile layer has increased and the fruit body has begun to be differentiated, the shield is still distinct and not connected with it at the margin. At this time the cells in the center of the young fertile stroma are thinner walled, with a more deeply staining content.

The asci are formed within the fertile stroma, arising from the basal portion, as shown in figs. 8 and 9. In this way the cells in the upper part of the fertile stroma persist, forming a delicate covering over the hymenium. The development of the asci within this fertile stroma is comparable with their origin in the apothecia of the Phacidiales. The hymenium arises in the same way, and the upper part of the stroma corresponds with the tissue which covers the hymenium before the opening of the apothecium. In the rose fungus, however, this covering is not so well developed and may not always persist to be folded back when the fruit body opens. It may form a continuous delicate layer over the asci until the fruit body is mature and only rupture together with the shield. In other cases this covering is broken by the development of the hymenial layer. Fragments may remain at the margin of the apothecium or they may disappear. It is only by the elongation of the asci and the consequent increase of pressure that the cuticle and shield, together with the upper part of the apothecium, are ruptured in an irregularly stellate manner and thrown back. The portions covering the hymenium have ruptured in fig. 11.

In the mature opened condition shown in fig. 12, the thin-walled cells of the upper part of the apothecium still persist on the margin of the fruit body. The opened perithecia present in surface view the appearance shown in fig. 5. The folding back of the shield is shown in section in fig. 15. The perithecia develop independently of the acervuli, as would be expected from the origin of the two. In fig. 13 is shown an old acervulus by the side of a perithecium. In none of the material which had wintered could acervuli be found which were bearing conidia.

The epidermal cells of the host persist for a long time, so that the ascogenous layer and shield are separated. They may become entirely destroyed as the asci elongate and the perithecium becomes mature (fig. 14), or they may persist on the margin of the mature perithecium (fig. 12). The perithecia vary in shape from spherical to discoid. One of the large discoid perithecia is represented in section in fig. 14. The septate, knobbed paraphyses extend between and beyond the asci until the time when the spores are nearly mature. Asci in many stages of development occur within each perithecium. Mature asci extend slightly beyond the paraphyses and the spores are discharged from an apical pore (fig. 16) formed by the rupture of the wall. The asci are oblong or subclavate, tapering above rather bluntly, and are 70–80×15 μ.

Apparently the spores are not discharged with violence. Agar plates were inverted above rose leaves in moist chambers, the surface of the agar coming nearly in contact with the leaf. No spores were observed to have lodged on the surface of the agar, as would be expected if they were projected forcibly from the asci. As far as I have been able to observe, they merely pile up in a whitish heap in the opened perithecium. The spores are 20–25×5–6 μ, varying extremely in form (fig. 17), as do the conidia. They resemble the conidia very much except that they are not so strongly constricted at the septum. They are hyaline and bicellular. Usually large granules and several guttulae are present in each cell. The cells are generally unequal in size, the upper one being broader.

Germination of ascospores

Considerable difficulty was experienced in germinating the ascospores. All attempts to employ artificial media have been unsuccessful. Spores from the same preparation have been used in poured and planted plates of bean agar, in hanging drops of water, in similar drops in which has been placed a small piece of green rose leaf, in infusions made by boiling green rose leaves in water, and in drops of water on rose leaves in a moist chamber. In no case has germination been secured in any other way than by the last method. Germination occurs within 24 hours, the larger cell more often germinating, although either cell is capable of germination. A germ tube is characteristically formed at one side near the end of the spore. This hypha soon branches and septa are laid down (fig. 18). Occasionally two tubes are formed from a single cell. In about 35 transfers of spores to bean pods made under aseptic conditions no growth was secured. From these and the foregoing experiments it would seem that the ascospores are dependent on some stimulus of the living plant for germination. There may be some advantage to the parasite in this, since many spores would germinate before they are able to reach a suitable location on the host.

Artificial infection

Ascospores were used in the infection experiments. Since they are discharged in such masses in the opened perithecia, they can easily be removed free of everything else. Several series of poured plates made from spores obtained in this way remained absolutely sterile, which indicated that no other spores except ascospores of the rose fungus had been carried over. The spore masses were first removed to a drop of sterile water on a slide. With a needle, then, some of the spores were transferred to drops of water on the leaves of living roses. The plants were then covered with bell-jars and were allowed to remain covered for two days. Infections from inoculations made April 27 were very evident by May 7, appearing as small black areas. By May 15 mature acervuli and conidia of the *Actinonema* type were formed, thus completing the life cycle and connecting the two forms. Inoculations were

also made in the same way on leaves placed in Petri dishes lined with moist filter paper. In four days the radiating strands were very evident with the aid of the low power of a microscope. Infection occurs by the entrance of the germ tube through the cuticle, there being no stomata on the upper surface of the leaves. From the subcuticular mycelium, hyphae later penetrate to the tissue below, first filling the epidermal cells, and only in the advanced stages of the disease penetrating the mesophyll.

The way in which this fungus hibernates is no longer a matter of conjecture. SCRIBNER[21] suggested that the spores lodge on the buds in autumn and remain there dormant until the leaves have expanded the following summer. As has been found to be true with many imperfect fungi, this fungus is carried through the winter on fallen leaves and the ascosporic stage develops in the following spring.

This study shows that *Gnomoniella rosae* (Fkl.) Sacc. is not the perfect stage of the rose *Actinonema*, as has recently been suggested.[22] One species of *Actinonema*, however, has been connected with an *Asterella*, *Actinonema rubi* (Fkl.) becoming *Asterella rubi* (Fkl.) v. Höhnel.[23] He found in the spring the *Asterella* stage on living canes of *Rubus Idaeus*. These areas had been occupied the previous summer by the conidial stage.

The genus *Asterella* was first proposed by SACCARDO[24] as a subgenus of *Asterina* for those species which have hyaline spores. Later [25] he raised *Asterella* to generic rank. As SACCARDO himself points out, further investigation of species which are at present placed in the genus *Asterella* will result in their transfer to *Asterina*, since the spores become brown at maturity. LINDAU[26] thinks the existence of this genus is still questionable. Subsequently but little investigation has been made on the genus and no clear-cut

[21] See footnote 7.

[22] LAUBERT, R., and SCHWARTZ, MARTIN, Rosenkrankheiten und Rosenfeinde. 16–19. 1910.

[23] VON HÖHNEL, F., Über *Actinonema rubi* Fuckel ist *Asterella rubi* (Fkl.) v. Höhnel. Ann. Myc. **3**:326. 1905.

[24] SACCARDO, P. A., Syll. Fung. **9**:393. 1891.

[25] ———, Syll. Fung. **1**:25 and 42. 1882.

[26] LINDAU, G., ENGLER and PRANTL'S Pflanzfam. **1**:340. 1897.

generic limits have been proposed. One finds included species whose spores become brown, some which are aparaphysate, some possessing filiform paraphyses, and others having paraphyses which are enlarged at the tips. In fact, the whole family Microthyriaceae is but little known, due in part to the fact that most of the forms are tropical. A thorough investigation of perithecial development is necessary, since very little attention has been given to this group. The family is at present characterized by having perithecia which are shield-shaped, thin membranaceous, flat, with a rounded pore at the top and with a membrane formed *only on the upper side*. With the exception of the species on rose leaves, which I have studied, it is not known whether or not the forms without an apical pore possess one at maturity. It has long been recognized, because of the entirely different manner of development, that the Microthyriaceae are widely separated from the other two families of the Perisporiales, the Erysiphaceae and the Perisporiaceae.

In order to see if other genera of the Microthyriaceae corresponded in structure and development with the forms on rose leaves several of them were examined. *Asterina orbicularis* B. & C., n. 231 of RAVENEL'S collections, forms entirely superficial perithecia, sending hyphae partially through the cuticle. *Asterina inquinans* E. & E., n. 1785 N.A.F., is also superficial, ends of the mycelium being observed in the stomata. *Asterina plantaginis* Ellis, n. 791 N.A.F., forms spherical perithecia entirely sunken within the host tissue. The perithecia are ostiolate and appear to have the characters of a *Sphaerella*. *Micropeltis longispora* Earle, n. 6349, plants of Porto Rico, is entirely superficial. *Microthyrium littigiosum* Sacc., collected at Frankfort, Germany, by Dr. PAUL MAGNUS, seems to form superficial perithecia, but the mycelium is present in the epidermal cells. *Myriocopron smilacis* (De Not.) Sacc., n. 600 E. & E., N.A.F., also forms superficial perithecia and the mycelium occurs in the stomata. None of these representative genera seem to be comparable to the type of development as exhibited by the rose fungus. Since so little is known of the perithecial development and the method of securing food supply of the Microthyriaceae, this family would afford an

excellent field for investigation. MAIRE[27] has described the organs of absorption of *Asterina usterii* and *Asterina typhospora*. A slender filament penetrates the epidermal wall and when it has reached the cavity of the cell it enlarges and becomes profusely branched.

The opened perithecia of the rose fungus present characters indicative of a close relationship to the Phacidiales. The ragged margin of the shield suggests the ruptured outer portion of the wall of the fruit body which at first covers the hymenium. The presence of knobbed paraphyses is also a character possessed by many Discomycetes. In the Phacidiales, however, as far as can be learned, the upper or outer part of the fruit body is not separate in origin from the ascogenous stroma, nor does it possess the characteristic structure, of the shield present in the Microthyriaceae. On the other hand, it is quite probable that few of the Microthyriaceae possess a stroma within the leaf tissue as has been described for the fungus in question. The majority are apparently superficial and with a well developed wall or shield *only on the upper side*. In spite of these facts, I feel that this fungus should be placed in the Microthyriaceae. Further morphological study of other species of this genus and related genera will throw some light on the relationship of these microthyriaceous forms. Perhaps the systematic position of many of these forms will be changed as soon as the species have been satisfactorily investigated. While the possession of the shield and the hyaline 2-celled spores are characteristics which would suggest the position of the rose fungus in the genus *Asterella*, yet, as has been pointed out, this genus is not clearly limited and contains heterogeneous elements. This fungus does not seem to accord morphologically with the members of this genus in the sense in which the genus was first employed. Species representing several generic types apparently have been included in *Asterella*. Since the characters presented by this fungus are evidently those of a distinct generic type, rather than place it in the genus *Asterella*, it seems better to treat it as the type of a new genus. Because of the two separate structures, the shield

[27] MAIRE, R., Les Suçoirs des *Meliola* et des *Asterina*. Ann. Myc. **6**:124–128. *fig. 4*. 1908.

and apothecium, the name *Diplocarpon*[28] is proposed. The following description of the genus is given.

Diplocarpon, nov. gen.—Fruit bodies formed in connection with an extensive subcuticular mycelium, consisting of a subcuticular circular shield with more or less radiate elements especially at the margin, and an innate apothecium. Shield, together with the radiating strands on which it is formed, dark brown, without a central pore. Apothecium at first separate from the shield, only joined here and there by hyphae which pass between the epidermal cells. Apothecium joined with the margin of the shield at maturity. Hymenium covered by the shield and upper part of the apothecium which at maturity rupture in an irregularly stellate manner. Asci oblong to subclavate, 8-spored; paraphyses unbranched; spores elongated, 2-celled, hyaline at maturity.

A conidial stage of the *Actinonema*-type occurs in one species.

Peritheciis scutulum subcutaneum et apothecium innatum constitutis; scutulo mycelio subcutaneo, lato extenso, atro-brunneolo insidiente; margine radialiter diffuso, contextu membraneo, astomate; apothecio innato, primo scutulo separato, maturitate margine adjuncto. Peritheciis centro stellatim laciniato-dehiscentibus; ascis oblongis; paraphysibus simplicibus; sporidiis oblongo-ellipticis, bicellularibus, maturitate hyalinis.

Actinonema uni speciei cujus statum conidicum sistit.

Since this study connects for the first time the ascosporic stage with the conidial stage of the black spot of rose leaves, a brief characterization of the species is added:

Diplocarpon rosae, n.n.

Syn. *Erysiphe radiosum* Fr. Observationes Mycologicae. 207. 1824. *Asteroma rosae* Lib. Mem. Soc. Linn. **5**:404–406. 1827. *Actinonema rosae* Fr. Summa. veg. Scand. 424. 1849. *Dicoccum rosae* Bon. Bot. Zeit. 282. 1853. *Marsonia rosae* Trail. Fung. Inverar. 46. 1889. *Marsonia rosae* Br. and Cav. Funghi parassiti n. 97. 1889.

Ascigerous stage.—Perithecia epiphyllous, spherical to disciform, 100–250 μ in diameter; upper part or shield dark brown, subcuticular, formed in conjunction with the radiating strands of mycelium, circular, with a more or less radiating structure toward the margin. Lower part of fruit body disciform, subepidermal, of several layers of pseudoparenchyma cells, the outer of which are dark brown,

[28] διπλόος, "double," καρπός, "fruit."

the margin at length breaking through the epidermis and here and there becoming connected with the margin of the shield. Fruit bodies closed at first, later opening by the rupturing of the shield together with the upper part of the apothecium in an irregularly stellate manner from the center. Asci oblong or subclavate, narrowed abruptly above, 70–80×15 μ, 8-spored; paraphyses slender, enlarged abruptly at the tip, often 1-septate. Spores oblong-elliptical, hyaline, unequally 2-celled, constricted at the septum, 20–25×5–6 μ; upper cell somewhat larger, cells usually guttulate.

Conidial stage.—Spots epiphyllous, large, dark brown or blackish, with an irregular radiating border, when numerous becoming confluent and sometimes involving the entire leaf. Mycelial strands composed of several filaments, at first hyaline, forming a subcuticular network. Internal mycelium connected through the epidermis with subcuticular mycelium. Acervuli subcutaneous, covered at first by the cuticle which ruptures irregularly; conidia 2-celled, often deeply constricted, straight or subfalcate, 18–25×5–6 μ, hyaline and guttulate.

Conidial stage appearing on rose leaves in summer and autumn often causing defoliation of the plants. Ascigerous stage appearing in the spring on fallen leaves which have remained on the ground.

Peritheciis epiphyllis, globosis v. disciformibus, 100–250 μ diam.; scutulo atro-brunneolo, subcutaneo, mycelio reticulato insidiente, orbiculare, margine plus minusve radioso. Apothecio primo epidermide tecto, demum margine scutuli adjuncto, in centro irregulari-stellato dehiscente. Ascis oblongis vel subclavatis, supra obtuse angustatis, 70–80×15 μ, octosporis; paraphysibus filiformibus, apice incrassatis, interdum 1-septatis; sporidiis oblongo-ellipticis, inaequaliter bicellularibus, ad septa constrictis, guttulatis, hyalinis, 20–25×5–6 μ.

Hab. in foliis dejectis Rosae sp.

Status conidicus: Maculis epiphyllis, atro-brunneis vel purpurascentibus, fibrillis e centro radiantibus, albido-arachnoideis; acervulis subcutaneis, sparsis, nigricantibus; conidiis constricto, 1-septatis, guttulatis, hyalinis, 18–25×5–6 μ.

Hab. in foliis vivis Rosae sp.

Susceptibility of the host

This disease occurs on nearly all the cultivated varieties of roses both out of doors and in the greenhouse. BRIOSI and CAVARA note that only four varieties, Rosa hybrida var. Belle

Angevine, Triomphe d'Alençon, Abel Grant, Rosa borboniaria var. Triomphe d'Anger, of the 600 growing in the botanical gardens at Pavia are free from the attacks of this fungus. LAUBERT and SCHWARTZ[29] call attention to the fact that the bushy sorts are more susceptible than climbing varieties, and also that thin-leaved species are most liable to attack. HALSTED[30] finds that a wild species, *Rosa humilis*, is also subject to attack when growing in a garden with diseased plants. The amount of loss caused is equaled or surpassed by only one other rose disease, the powdery mildew.

Control measures

This disease has been very satisfactorily controlled by the use of any of the standard copper compounds. Since now we know that the fungus winters over in the fallen leaves, sanitary measures may better be employed in combating the disease. If all the leaves are gathered together and burned either late in the autumn or early in the spring, before the new leaves have expanded, the chances of infection would be greatly lessened.

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AGRICULTURAL EXPERIMENT STATION
AUBURN, ALABAMA

NOTE.—Since this manuscript has been sent to the publishers, I have received type specimens of *Asterella rubi*, which had been sent to Professor GEORGE F. ATKINSON, through the courtesy of Professor F. VON HÖHNEL. Because of the fact that *Asterella rubi* is the first *Asterella* to be connected with an *Actinonema*, and is one of the most recently described species of this genus, it is especially important that it be compared morphologically, with the rose fungus.

For the study of the structure of the fruit bodies of *Asterella rubi* the cortex of some of the affected raspberry canes was imbedded in paraffin and sectioned. The perithecia were found to possess a central pore or ostiolum. They are *entirely* superficial and with a well developed structure only on the upper side. There is no well defined stroma from which the asci arise.

By treating small pieces of the cortex with lactic acid the entire shield may

[29] See footnote 22.

[30] HALSTED, B. D., New Jersey Agr. Exp. Sta. Rept. **13**:281. (1892) 1893.

be loosened, and can be floated away, thus proving beyond a doubt that this structure is wholly superficial and not subcuticular. *Asterella rubi*, therefore, conforms to the present concept of the genus *Asterella*, but is of an entirely different generic type from that represented by *Diplocarpon rosae*.

EXPLANATION OF PLATE XIII

FIG. 1.—Acervulus of conidial stage (*Actinonema rosae*), with a section of one of the radiating strands at the right of the acervulus; ×400.

FIG. 2.—Conidia formed free in culture; the two halves are easily separable; germination of the separated cells; ×400.

FIG. 3.—Normal conidia from acervuli, and their method of germination; ×400.

FIG. 4.—Surface view of *Diplocarpon rosae*, showing the shield and subcuticular strands from which it developed; ×110.

FIG. 5.—Surface view of mature perithecia in which the shield has been ruptured irregularly and folded back; ×55.

FIG. 6.—A very young stage in the development of a fruit body in which the shield and the stroma from which the asci are formed are distinct; *C*, cuticle; *B*, epidermal cells; *D*, ascogenous stroma; ×200.

FIG. 7.—A stage in which the fruiting part of the perithecium has begun to be differentiated; the shield and ascogenous stroma are separate; *A*, young apothecium; ×200.

FIG. 8.—Differentiation of the asci within the apothecium; ×200.

FIG. 9.—Perithecium in which the epidermal cells still persist between the apothecium and shield; the thin-walled cells of the upper part of the apothecium form a covering over the hymenium; ×200.

FIG. 10.—Perithecium in about the same stage of development as fig. 9, but the shield and fertile stroma are completely united; ×200.

FIG. 11.—Perithecium which is nearly mature; the hymenial covering has broken; *A*, upper part of apothecium; *B*, shield; *C*, cuticle; *E*, epidermal cells; ×200.

FIG. 12.—Mature fruit body of *Diplocarpon rosae;* some of the cells of the upper part of the apothecium persist at the margin; ×200.

FIG. 13.—An old acervulus persisting at the side of a perithecium; ×200.

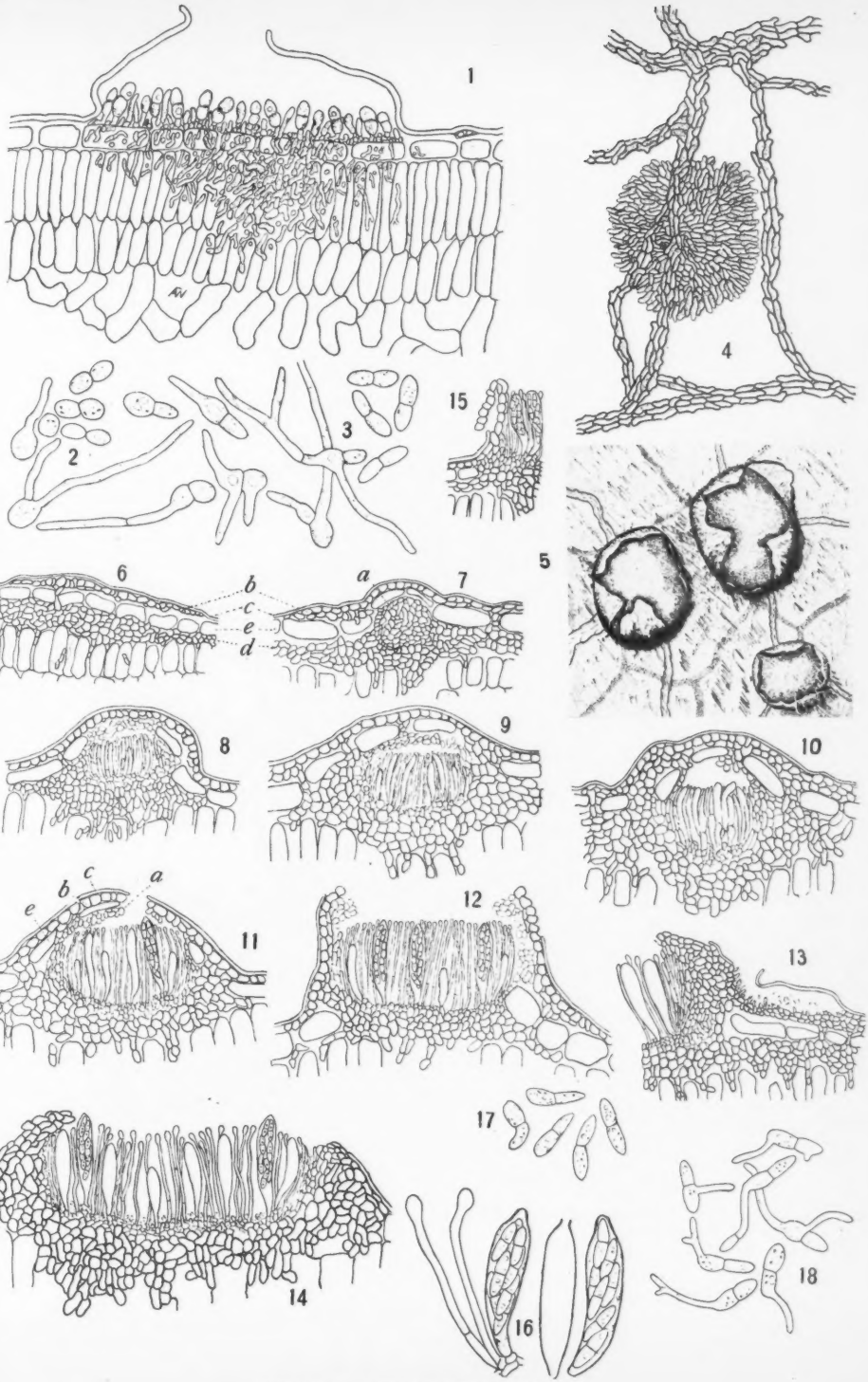
FIG. 14.—A large disciform perithecium; some asci are mature and in others the spores have not yet been formed; the ascogenous stroma and shield have grown together and the epidermal cells have been destroyed; ×200.

FIG. 15.—Section through a mature perithecium, showing the manner in which the shield is folded back; ×200.

FIG. 16.—Mature asci and paraphyses; the spores have been discharged apically from one ascus; ×400.

FIG. 17.—Ascospores of *Diplocarpon rosae;* ×400.

FIG. 18.—Germination of ascospores; ×400.



WOLF on ACTINONEMA ROSAE

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXXV[1]

JOHN DONNELL SMITH

Rigiostachys quassiaefolia Donn. Sm.—Folia maxima 3–5-foliolata, rhachi petioloque alatis. Racemi axillares petiolo pluries breviores. Sepala minuta deltoidea. Discus vix ullus. Ovaria obovoidea, stylis lateralibus, ovulis geminis.

Omnino glabra. Foliola plerumque 5 sessilia integra lanceolato-elliptica utrinque acuminata, terminali ceteris paulo majore 12–14 cm. longo 4.5–5 cm. lato, rhachi oblanceolata 3.5–4 cm. longa 8–10 mm. lata, petiolo 3.5–5.5 longo anguste alato. Racemi e basi floriferi circiter 10-flori rhachis 4–5 mm. longa crassa paleaceo-bracteosa, pedicelli 1.5–2.5 mm. longi. Sepala aegre 1 mm. longa. Petala oblongo-elliptica 3.5 mm. longa. Gynophorum leviter compressum 1 mm. altum atque latum. Ovaria leviter compressa 2 mm. longa mox libera, stylis praeter stigmata diu connexa discretis, ovulis paulo supra basin loculi affixis. Cetera desunt.—Specimina incompleta speciem quamvis abnormem tamen satis certam *Rigiostachydis* sistere videntur.

Panzal, Depart. Baja Verapaz, Guatemala, alt. 1000 m., Apr. 1907, *H. von Tuerckheim* n. II. 1714.

Eugenia (Sect. AUTEUGENIA Niedenzu; § *Biflorae* Berg.) **fiscalensis** Donn. Sm.—Glabra. Folia coriacea ex orbiculari-ovato ovata gradatim obtuseque acuminata basi rotundata. Pedunculi axillares singuli vel bini, pseudo-terminales 6–8-ni, petiolo bis terve floribus paulo longiores basi et sub flore bibracteolati. Petala oblongo-elliptica.

Arbusculus 6-metralis, ramulis dichotomis, novellis compressis purpurascentibus punctulatis, internodiis folio brevioribus. Folia nitida concoloria supra pellucido-subtus-fusco-punctulata 30–37 mm. longa 17–25 mm. lata, margine cartilagineo revoluto, nervis praeter medium supra impressum subtus prominentem parum manifestis, petiolo canaliculato 2–3 mm. longo. Pedunculi 5–7 mm. longi basi et sub flore articulati punctulati, bracteolis eciliolatis, basalibus lineari-lanceolatis 1.5 mm. longis, apicularibus subulatis vix 1 mm. longis, floribus praeter discum pubescentem glabris. Calycis tubus hemisphaericus 1.5 mm. altus, lobi semiorbiculares concavi trinervii inaequales 1–2 mm. longi in alabastro erubescentes. Petala punctulata 4.5 mm. longa

[1] Continued from BOT. GAZ. **52**:53. 1911.

genitalibus subaequilonga. Discus 2 mm.-diametralis. Bacca ignota.—*E. surinamensi* Miq. proxima.

In praeruptis *Barranca* dictis prope Fiscal, Depart. Guatemala, Guatemala, alt. 1100 m., Jun. 1909, *Charles C. Deam* n. 6226.—Typus in herb. Musei Nationalis numero proprio 579586 signatus servatur.

Anguria pachyphylla Donn. Sm.—Folia trifoliolata, foliolis breviter petiolulatis coriaceis acuminatis integris, terminali obovato basi cuneato, lateralibus oblongo-ovatis asymmetricis. Flores masculini sessiles. Calycis dentes minuti. Antherae lineares, appendice ovali glabra, loculis rectis.

Robustissima glaberrima resinulas exsudans. Caulis cum petiolo communi 3–3.5 cm. longo crassus angulato-sulcatus compressus. Foliola subaequalia 16–22 cm. longa 8.5–11 cm. lata acute incurvo-acuminata margine integerrima nervis validis subtus elevatis utrinque 7–8 penninervia aetate provectiore glandulis resinosis adspersa in sicco supra glaucescentia subtus pallidiora, foliola exteriora inaequilateralia basi intus acuta extus late rotundata, petiolulis complanatis 8–12 mm. longis. Cirrhi crassimi longissimi teretes striati. Pedunculi tantum masculini suppetentes 25–40 cm. longi complanati striati, spica 9–13 mm. longa resinosa, floribus 20–26 ex schedula Tonduziana latericiis. Calyx ellipsoideo-oblongus 9 mm. longus 3 mm. latus striatus faucibus haud constrictus basi obtusus, dentibus crassis triangularibus 1 mm. longis glandula saepius apiculatis. Petala erecta carnosa subtus elevato-costata ceterum enervia utrinque dense papillosa ungue 0.5 mm. longo exempto orbicularia 3 mm.-diametralia. Antherae 8 mm. longae 1 mm. latae, appendice 1 mm. longa. Flores feminini et fructus desiderantur.—*A. pallidae* Cogn. proxima.

In apricis ad praedium *Tuís* dictum, Prov. Cartago, Costa Rica, alt. 650 m., Nov. 1897, *Adolfo Tonduz* n. 11535.—In fruticetis apud Las Vueltas, Tucurrique, Prov. Cartago, Costa Rica, alt. 635 m., Apr. 1899, *Adolfo Tonduz* n. 13007.

CUCURBITACEARUM duas species ineditas peregrinas fas mihi sit hoc loco describere, nempe:

Anguria tabascensis Donn. Sm.—Folia dimorpha profunde bipartita vel trifoliolata. Flores masculini spicati. Calycis tubus triente superiore angustatus, dentes elongato-triangulares. Antherae breves oblongae submuticae, loculis rectis.

Glabra. Caulis tenuis striatus sulcatus. Petioli 17–27 mm. longi. Foliorum segmenta vel foliola cuspidata margine sinuosa penninervia, bipartitorum segmentum alterum oblongum 15 cm. longum 8 cm. latum intrinsecus excisum extrinsecus basi 3.5 cm. lata truncatum altero lanceolato-oblongo bis majus, trifoliatorum foliolum terminale obovatum 10 cm. longum 5 cm. latum deorsum attenuatum, lateralia oblonga 9 cm. longa 4 cm. lata intrinsecus excisa

extrinsecus basi rotundata, petiolulis 6–7 mm. longis. Cirrhi compressi striati. Pedunculi solum masculini visi striati sulcati 17–25 cm. longi, spica 4–5 cm. longa. Calycis tubus striatus subcylindricus 10 mm. longus basi obtusus, dentes 2 mm. longi erecto-patuli. Petala erecto-patula utrinque leviter furfuracea ungue 1 mm. longo atque lato exempto orbicularia 6 mm.-diametralia. Antherae 4 mm. longae 1.5 mm. latae, appendice minutissima papillosa. Flores feminini et fructus ignoti.—Ad *A. diversifoliam* Cogn. floribus arcte accedens ab ea foliis longe distat.

Ad ripas paludosas fluminis *Macayal* dicti, Comarca de Tabasco finibus Guatemalensibus adjacens, Mexico, Jul. 1889, *José N. Rovirosa* n. 519.

Gurania brachyodonta Donn. Sm.—Folia pedatim 5-foliolata, foliolis integris vel vix lobatis, interioribus obovatis deorsum attenuatis, extimis semiovatis. Flores masculini racemosi. Calycis dentes subulati tubo 2–4-plo petalis paulo breviores. Antherae lanceolato-oblongae, appendice papillosa, loculis replicatis.

Caulis tenuis cum petiolo communi complanato 5.5–9 cm. longo striatus sulcatus parce patenterque pilosus. Foliola tenuiter membranacea acute acuminata minute remoteque spinuloso-denticulata supra bulboso-pilosiuscula subtus nervis pubescentia, terminale 10.5–16.5 cm. longum 4–6 cm. latum integrum vel latere altero ad medium repando-vel angulato-sublobatum, intermedia paulo minora integra, extima 7–9 cm. longa 3.5–4.5 cm. lata intrinsecus excisa extrinsecus basi late rotundata integra vel ad instar terminalis sublobata, petiolulis propriis atque communibus complanatis striatis glabrescentibus. Cirrhi tenues striati glabrescentes. Pedunculi tantum masculini visi 9.5–14 cm. longi tenues striati glabri, racemo 7 mm. longo, pedicellis 3–22 puberulis 4–7 mm. longis, floribus ex scheda cl. repertoris luteis. Calycis ferme glabri tubus ovoideo-oblongus 6–9 mm. longus 3–4 mm. latus apice vix constrictus basi cuneatus, dentes 2–2.5 mm. longi erecto-patentes. Petala erecto-patentia oblonga 3 mm. longa 1 mm. lata acuta trinervia extus leviter papillosa. Antherae 3–4 mm. longae 1 mm. latae, appendice 0.5 mm. longa, connectivo angusto. Flores feminini et fructus ignoti.—*G. pedatae* Sprague proxime affinis differt calycis dentibus in genere brevissimis.

Ad praedium *El Recreo* dictum, Prov. Manabi, Ecuador, *Eggers* n. 15084.—In silvis prope Balao, Ecuador, Maj. 1892, *Eggers* n. 14691.

GARYA LAURIFOLIA Benth., var. **quichensis** Donn. Sm.—Folia nitida integerrima. Inflorescentia masculina densissimiflora, spicis corymboso-paniculatis suberectis abbreviatis, nodis et spiciferis et floriferis approximatis.

Frutex 2–3-metralis totus siccitate nigricans. Paniculae ex solis exemplis masculinis notae 4–6 cm. longae, internodiis 1 cm. non excedentibus.

Versus cacumen montis haud procul a San Miguel Uspantán siti, Depart. Quiché, Guatemala, alt. 1800 m., Apr. 1892, *Heyde* et *Lux*, n. 3175 ex Pl. Guat. etc. quas ed. Donn. Sm.

Alloplectus ruacophilus Donn. Sm.—Folia oblongo-elliptica vel-lanceolata utrinque acuminata mucrone denticulata. Pedunculi numerose aggregati inaequilongi. Calyx leviter obliquus, segmentis parum inaequalibus inciso-dentatis. Corolla calyce bis longior cylindracea postice saccata ore obliqua, lobis subaequalibus brevibus obtusis. Antherae rotundato-quadratae.

Caulis obtuse tetragonus glabrescens epidermatis squamellis retroversis interdum munitus ad apicem versus pilosus flavicans. Folia leviter disparia papyracea pellucida discoloria supra sparsim paleaceo-strigillosa subtus nervis fuscis pilosa ceterum strigillis minutis conspersa 15–20 cm. longa 5–6 cm. lata, nervis lateralibus utrinque 6–7 marginem ultra medium attingentibus, petiolis pilosis 2.5–5.5 cm. longis ad articulationem glandula sanguinea utrinque munitis. Pedunculi 6–12-ni 1–3 cm. longi pilosi bracteis sanguineis integris extus pilosis lanceolato-ovatis 1–1.5 cm. longis fulti. Calycis sanguinei segmenta basi extus pilosa ceterum subglabra, quatuor lanceolato-ovatis 1.5 cm. longis 7 mm. latis, quinto aequilongo dimidio angustiore, dentibus lateralibus utrinque 7 sicut apex nigro-mucronulatis. Corolla erubescens villosa 28–30 mm. longa 7 mm. lata recta vix ventricosa faucibus haud contracta, lobis 1.5 mm. longis. Stamina ad 4 mm. supra basin corollae inserta 16 mm. longa, antheris 2 mm. longis atque latis. Disci glandula solitaria. Ovarium ovoideum villosum. Fructus ignotus.—Ad *A. tetragonum* Hanst. et *A. Ichthyodermatem* Hanst. arcte accedens differt praesertim corolla.

In silvis montis vulcanici *Barba* dicti, Prov. Heredia, Costa Rica, alt. 2500–2700 m., Febr. 1890, *Adolfo Tonduz* n. 1997.—Volcán Poás, Prov. Alajuela, Costa Rica, alt. 2400 m., Mart. 1896, *John Donnell Smith*, n. 6729 ex Pl. Guat. etc. quas ed. Donn. Sm. (Specimina sub *A. Ichthyodermate* Hanst. olim distributa.)—In silvis ad Achiote in monte vulcanico *Poás* dicto, Prov. Alajuela, Costa Rica, alt. 2200 m., Dec. 1896, *Adolfo Tonduz* n. 10799.

Alloplectus tucurriquensis Donn. Sm.—Folia obovato-elliptica sensim acuminata deorsum attenuata in petiolum decurrentia inaequilateralia crenulato-denticulata. Pedicelli in racemo brevissimo dense aggregati bractea sanguinea fulti. Calyx leviter obliquus pedicello subdimidio longior plus minus sanguineus, segmentis subaequalibus oblongis integris. Antherae oblongae.

Caulis epiphytalis glaber. Folia 18–28 cm. longa 9–14 cm. lata pergamentacea supra strigilloso-pubescentia subtus puberula grosse reticulata, nervis lateralibus utrinque 9–10, petiolis 2–4 cm. longis tenuibus alatis. Racemorum

in exemplo unico suppetente haud satis evolutorum pedunculus 5–7 mm. longus, pedicelli subfasciculati 13–18 mm. longi, bracteae optime ellipticae 26–33 mm. longae 13–17 mm. latae integrae reticulato-venosae deciduae. Calyx 20–28 mm. longae ad tres partes partitus extus puberulus intus glaber irregulariter sanguineo-maculatus, segmentis obtusis reticulato-venosis. Corolla tantum immatura cognita pubescens. Antherae 5 mm. longae. Disci glandula solitaria. Ovarium cinereo-pubescens oblongo-ovoideum 8 mm. longum. Fructus ignotus.—*A. macrantho* Donn. Sm. quam maxime affinis.

In silvis prope Las Vueltas, Tucurrique Prov. Cartago, Costa Rica, alt. 635–700 m., Mart. 1899, *Adolfo Tonduz* n. 13042.

Alloplectus oinochrophyllus Donn. Sm.—Folia leviter disparia obovato-elliptica sursum cuspidato-deorsum cuneato-acuminata integra subtus vinicoloria. Calyx virescens basi saccatus, segmentis parum inaequalibus lanceolato-ovatis integris. Corolla recta triente lobata. Antherae oblongae.

Epiphytalis, caule subtetragono rufescente articulato-piloso, internodiis, 4–7 cm. longis. Folia ferme glabra 8–12 cm. longa 3–5 cm. lata, altero in pare subtriente minore, plerumque inaequilateralia falcata, nervis lateralibus utrinque 4–5 subtus fuscentibus, petiolo piloso 1–2 cm. longo. Pedunculus in utraque axilla solitarius teres pilosus 7–9 mm. longus bracteis sanguineis lanceolatis 13 mm. longis fultus, floribus minute parceque strigillosis. Calycis segmenta basi connata 30–32 mm. longa 13–17 mm. lata longe attenuata, postico ceteris simili eis paulo minore. Corollae albae (cl. repertor in schedula), venuloso-reticulatae tubus supra basin saccatam leviter ventricosus dein sensim paulo ampliatus faucibus haud constrictus 3 cm. longus, limbus obliquus, lobi suborbiculares 1 cm. longi crenulati. Stamina ad 7 mm. supra basin corollae inserta, filamentis 15 mm. longis, antheris 5.5 mm. longis basi discretis. Disci glandula solitaria acute ovata 2 mm. longa. Ovarium ovoideum cum stylo 8–10 mm. longo pubescens, stigmate bilobo. Fructus desideratur.—*A. strigoso* Hanst. affinis.

In silvis ad Pansamalá, Depart. Alta Verapaz, Guatemala, alt. 1250 m., Maj. 1887, *H. von Tuerckheim*, n. 1080 ex Pl. Guat. etc. quas ed. Donn. Sm. (Sub *A. strigoso* Hanst. olim distributus.)—In silvis montanis prope Cobán, Depart. Alta Verapaz, Guatemala, alt. 1350 m., Aug. 1907, *H. von Tuerckheim* n. II. 1918.

Quum *Alloplecti* quaedam species in America Centrali nuperius repertae sub sectionibus auctorum non satis bene militent, clavis specierum Centrali-Americanarum adhibeatur nova opportet.

I. Calyx regularis.
  A. Antherae oblongae. *A. multiflorus* Hanst.
  B. Antherae rotundato-quadratae. *A. calochlamys* Donn. Sm.

II. Calyx leviter obliquus.
  A. Antherae latiores quam longiores. *A. tetragonus* Hanst.
  B. Antherae rotundato-quadratae.
    1. Caulis squamelliferus.
      a. Corolla calycem paulo superans. *A. Ichthyoderma* Hanst.
      b. Corolla calycem bis superans. *A. ruacophilus* Donn. Sm.
    2. Caulis nudus.
      a. Calycis segmenta inciso-crenata. *A. Forseithii* Hanst.
      b. Calycis segmenta filiformi-laciniata.
        † Folia in pare aequalia. *A. costaricensis* Dalla Torre et Harms.
        †† Folia in pare dimorpha. *A. metamorphophyllus* Donn. Sm.
  C. Antherae oblongae.
    1. Folia peltata. *A. pellatus* Oliver
    2. Folia basi petiolata.
      a. Flores singuli aut fasciculati. *A. macrophyllus* Hemsl.
      b. Flores racemosi.
        † Bracteae virescentes. *A. macranthus* Donn. Sm.
        †† Bracteae sanguineae. *A. tucurriquensis* Donn. Sm.

III. Calyx basi saccatus.
  A. Calycis segmenta parum inaequalia.
    1. Folia concoloria. *A. strigosus* Hanst.
    2. Folia subtus vinicoloria. *A. oinochrophyllus* Donn. Sm.
  B. Calycis segmentum posticum ceteris multo minus.
    1. Pedunculus multiflorus. *A. ventricosus* Donn. Sm.
    2. Pedunculi uniflori.
      a. Pedunculi bini. *A. stenophyllus* Donn. Sm.
      b. Pedunculi 4–5-ni. *A. coriaceus* Hanst.

Besleria (§ GASTERANTHUS Benth.) **acropoda** Donn. Sm.—Folia lanceolato-elliptica utrinque acuminata serrata. Pedunculi pseudo-terminales bini triflori. Calyx amplus, segmentis integris. Corolla prona infundibuliformis calyce subtriplo longior in saccum inflatum segmento calycino pendulo paulo breviorem producta.

Frutex terrestris, ramis junioribus subtetragonis sulcatis strigilloso-pubescentibus. Folia membranacea supra glabra subtus nervis venulisque pubescentia ceterum albo-maculata supra medium grosse remoteque serrata 10–13 cm. longa 4.5–5.5 cm. lata in eodem jugo parum aequalia, nervis lateralibus utrinque 8–9, petiolis 1–2 cm. longis strigilloso-pubescentibus. Pedunculi tantum ad rami apicem siti ramulo nascente comitati demum axillares ita solitarii evadentes 15–25 mm. longi glabri, pedicellis 7–10 mm. longis glabris, floribus pube moniliformi adspersis. Calycis herbacei valde obliqui segmenta fere sejuncta, antica lanceolata 12 mm. longa, lateralia lanceolato-ovata 14 mm.

longa valde inaequilateralia semicordata, posticum orbiculari-ovatum 10 mm. longum graciliter cuspidatum. Corollae luteae tubus 3 cm. longus leviter ventricosus parum incurvatus limbi amplitudine subtriplo longior, saccus pendulus ellipsoideus 8–9 mm. longus segmento calycino postico semiamplectus, os obliquum, lobi breves arcuati. Stamina paulo supra basin tubi inserta 9 mm. longa, antheris suborbicularibus. Discus postice incrassatus. Ovarium glabrum valde obliquum ovatum 3 mm. longum, stylo 8 mm. longo. Fructus ignotus.

In silvis ad Tsaki, Talamanca, Comarca de Limón, Costa Rica, alt. 200 m., Apr. 1895, *Adolfo Tonduz* n. 9554.

Phyllanthus (§ EUPHYLLANTHUS Griseb.) **leptobotryosus** Donn. Sm.—Folia inter maxima coriacea nitida oblongo-elliptica utrinque acuta, petiolo apice incrassato geniculato. Flores dioici. Thyrsi masculini pluri-aggregati capillacei flaccidi pubescentes, calycis segmentis disci glandulas liberas bis superantibus, filamentis totis fere connatis.

Arborescens ut videtur. ramulis glabris, novellis angulosis. Folia 12–20 cm. longa medio 5–8 cm. lata concoloria minute reticulata areolis pellucida, nervis lateralibus fortioribus utrinque 6–7, petiolis 18–23 mm. longis canaliculatis, stipulis nullis. Thyrsi tantum masculini visi 3–11 e pulvinulo oblongo-elliptico pubescente progredientes pedunculo 2–4 cm. longo computato 4–10 cm. longi laxe ramosi parce flori minute bracteolati, pedunculo rhachi axibus trichoideis, cymulis trifloris, flore medio subsessili, pedicellis lateralibus 1 mm. longis. Calycis 6-partiti segmenta parce pubescentia rhomboideo-ovalia 1 mm. longa medio incrassata margine membranacea. Disci glandulae obovatae filamenta subaequantes. Antherarum rimae horizontales.

Santo Domingo de Golfo Dulce, Comarca de Puntarenas, Costa Rica, Mart. 1896, *Adolfo Tonduz*, n. 7332 ex Pl. Guat. etc. quas ed. Donn. Sm. (n. 9937 herb. nat. Cost.).

Hieronyma guatemalensis Donn. Sm.—Folia supra sparsim subtus densissime lepidota obsolete pilosa oblongo-obovata vel-elliptica acuminata deorsum attenuata petiolo multoties longiora. Pedicelli masculini bracteolam aequantes calyce dimidio breviores, floribus pentameris.

Ramuli petioli racemi calyces ad instar paginae inferioris foliorum lepidoti ceterum glabri. Folia 8–11 cm. longa 3.5–4.5 cm. lata incurvo- vel cuspidato-acuminata supra lepidibus albis punctata subtus lepidibus contiguis vel imbricatis rubiginosis obtecta, petiolo canaliculato 2–2.5 cm. longo, stipulis deciduis. Racemi tantum masculini visi ad apicem ramuli versus conferti paniculato-ramosi 5–8 cm. longi, bracteis deciduis, bracteolis late ovatis 1 mm. longis acutis. Calyx depresso-campanulatus 1.5 mm. altus, dentibus 5 triangularibus

minutis. Discus cupulatus 5-partitus extus glaber intus glandulosus pubescens. Stamina 5, filamentis glabris 1.8 mm. longis, loculis ovoideis 0.3 mm. longis. Ovarium rudimentarium exiguum. Flores feminini et fructus desunt.—Ex affinitate *H. oblongae* Muell. Arg.

In silvis prope Cobán, Depart. Alta Verapaz, Guatemala, alt. 1400 m., Apr. 1879, *H. von Tuerckheim*, n. 423 ex *Flora Guat. a Keck edit.*—In summo jugo inter Tactic et Cobán, Depart. Alta Verapaz, Guatemala, alt. 1850 m., Apr. 1908, *H. von Tuerckheim* n. II. 2228.

Ab hac specie specimina a *Herbert H. Smith* in Colombia lecta numero 1952 signata sub nomine erroneo ut videtur, nempe *H. laxiflora* Muell. Arg., distributa nonnisi foliis basi vix attenuatis costa pilosis et floribus subsessilibus distingui possunt.

Croton (Sect. EUTROPIA Muell. Arg.; § Cyclostigma Griseb.) **verapazensis** Donn. Sm.—Folia petiolo longiora ovata sensim acuminata basi rotundata subquinquenervia utrinque sparsim stellato-pilosa. Petiolus apice stipitato-biglandulosus. Stipulae subulatae. Racemi distanter fasciculiflori, bracteis linearibus. Stamina circiter 15. Styli bis terve divisi.

Indumentum pilo centrali elongato stellatim pilosum in ramulis petiolis foliis nascentibus racemis calycibus ovariis ochraceo-tomentulosum. Folia membranacea utrinque viridia 8–10 cm. longa 5.5–7.5 cm. lata glandulis minutis denticulata, petiolo 3–4.5 cm. longo, stipulis primum setaceis denique validioribus 4 mm. longis. Racemi 12–13 cm. longi, bracteis cito deciduis 5 mm. longis, inferioribus flores femininos simulque masculinos, reliquis tantum masculinos, fulcientibus, pedicellis masculinis quam feminina parum longioribus 3–5 mm. longis. Calycis segmenta fere sejuncta oblongo-ovata, feminina 2.5 mm. longa masculinis paulo majora margine plana. Petala masculina oblongo-elliptica 2.5 mm. longa scariosa villosa, feminina rudimentaria setacea aegre 1 mm. longa. Stamina 12–18, filamentis fere glabris 3 mm. longis, antheris subquadratis 0.5 mm. longis. Discus masculinus villosus, glandulis remotis orbicularibus, femininus glandulis contiguis crenulatis circumdatus. Ovarium subglobosum 2 mm.-diametrale, stylis plerumque bis dichotome partitis. Capsula stellatim pubescens 1 cm. longa, seminibus 5 mm. longis fuscis leviter rugosis.—Ad *C. hemiargyrium* Muell. Arg. accedens.

Santa Rosa, Depart. Baja Verapaz, Guatemala, alt. 1600 m., Jul. 1908, *H. von Tuerckheim* n. II. 2297.

Croton (§ DREPADENIUM Muell. Arg.) **Tuerckheimii** Donn. Sm.—Folia coriacea nitida oblongo- vel obovato-elliptica acuminata basi obtusiuscula vel acuta penninervia denticulata. Flores masculini axillares racemosi. Calyx 6–12-lobatus, receptaculo explanato tubum fere implente toto glandifero. Stamina numerosissima.

Arbor formosa (cl. repertor in literis), omnibus in partibus glaberrima, ramulis petiolisque glandulosis, novellis complanatis glaucis. Folia alterna 7–9.5 cm. longa 3–4 cm. lata incurvo- vel cuspidato-acuminata margine cartilagineo revoluta glandulis remote minuteque denticulata, petiolo canaliculato 7–12 mm. longo. Pedunculus communis in axillis superioribus situs vix ullus vel usque ad 7 mm. longus, pedicellis 5–7 corymboso-subfasciculatis 7–14 mm. longis, bracteis bracteolisque scariosis semiamplexicaulibus obtuse ovatis 2–2.5 mm. longis, floribus tantum masculinis cognitis. Calycis lobi plerumque 8 cuspidato-ovati vel -triangulares parum aequales 1.5–2 mm. longi, receptaculo 4–6 mm. lato glandis compactis compresso-subcubicis 0.5 mm. longis obsito. Petala obsoleta. Stamina inter glandas inserta 60–85, filamentis 3–3.5 mm. longis, antheris ovalibus 1 mm. longis prope basin affixes. Flores feminini et fructus ignoti.

Apud pagum *Tactic* dictum, Depart. Alta Verapaz, Guatemala, alt. 1550 m., Mart. 1908, *H. von Tuerckheim* n. II. 2163.

Acalypha (§ ACROSTACHYAE Muell. Arg.) **radinostachya** Donn. Sm.—Dioica. Folia oblongo-ovata crenato-serrata 3-nervia. Stipulae lineari-lanceolatae perlonge setaceo-productae. Spica feminina gracilis longissima, bracteis dissitis unifloris deltoideo-ovatis subintegris. Styli toti numerosissime longissimeque lacinuligeri.

Suffrutex erectus vix metralis simplex, caule petiolis foliorum nervis spica bracteis sparsim minuteque strigillosis. Folia nascentia der se luteo-strigillosa, adulta glabrescentia tenuiter membranacea 13–14.5 cm. longa 7–8.5 cm. lata graciliter acuminata basi rotundata leviter retusa, suprema conferta, petiolo 2.5–4 cm. longo ad apicem glandulis binis oblongis 1 mm. longis instructo, stipulis seta 10 mm. longa computata 17 mm. longis. Spica solum feminina nota terminalis sessilis usque ad 32 cm. longa. Bracteae 2 mm. longae atque latae acuminatae utrinque glandulis stipitatis minute 2–3-denticulatae. Sepala 3 ovata acuta 1 mm. longa. Ovarium globosum sepala aequans cum illis parce strigillosum, stylis 2 mm. longis, quoque lacinulis circiter 20–25 capillaceis simplicibus usque ad 6 mm. longis albidis biseriatim pectinato. Cetera desunt.

In silvis primaevis profundis ad fundum *Suerre* dictum, Llanuras de Santa Clara, Comarca de Limón, Costa Rica, alt. 300 m., Febr. 1896, *John Donnell Smith*, n. 6849 ex Pl. Guat. etc. quas ed. Donn. Sm.

Conceveiba (§ VECONCIBEA Muell. Arg.) **pleiostemona** Donn. Sm.—Folia suborbicularia vel orbiculari-obovata abrupte cuspidata basi rotundata vel retusa. Pedicelli masculini singuli vel 2–4-ni inaequales medio articulati calycem nutantem subaequantes. Stamina circiter 50–60.

Ex scheda cl. repertoris arbuscula, ramulis stipulis petiolis foliorum utrinque nervis panicula stellatim griseo-pubescentibus. Folia nascentia densissime praesertim in nervis utrinque tomentulosa, adulta praeter nervos supra glabrescentia venis venulisque subtus stellatim puberula pergamentacea concoloria pellucida glandulari-denticulata penninervia 13.5–18 cm. longa, 10–13.5 cm. lata, cuspide 1 cm. longa obtusa, nervis lateralibus utrinsecus 5–6, venis transversis 3–4 mm. inter se distantibus, petiolo striato 5–7.5 cm. longo, stipulis subulatis 5–6 mm. longis persistentibus. Panicula ex solis speciminibus masculinis nota sessilis 12–18 cm. longa, ramis erecto-patentibus, pedicellis plerumque trinis 2–3 mm. longis, articulo inferiore tomentuloso, superiore nitido, bractea bracteolisque ovato-lanceolatis 1–2 mm. longis. Calyx nitidus globosus 2.5 mm.-diametralis 2–3-partitus, segmentis demum reflexis. Stamina omnia antherifera conformia, filamentis glabris 7–11 mm. longis, antheris ob loculos late separatos latioribus quam longioribus. Flores feminini fructusque deficientes.—Affinitas cum *C. latifolia* Benth. summa est.

Ad ripas Río Blanco in fundo *Rosario* dicto, Llanuras de Santa Clara, Comarca de Limón, Costa Rica, alt. 300 m., Jul. 1899, *H. Pittier* n. 13425.

Ampelocera hondurensis Donn. Sm.—Aculeata. Folia integerrima obovato-elliptica obtusiuscula basi cuneata. Paniculae foliis 2–3-plo breviores. Perianthium quinquefidum, segmentis obovatis integris. Stamina 11–14, antheris in alabastro reversis. Ovarium ellipsoideum stylis subtriplo superatum.

Arbuscula (cl. repertor in scheda), omnibus in partibus glabra cortice griseo lenticellata spinis axillaribus rectis 5–11 mm. longis armata. Folia subcoriacea nitida 8–12 cm. longa 3.5–5 cm. lata a basi penninervia, nervis lateralibus late patulis utrinque 8–10, petiolo 4–8 mm. longo. Paniculae utriusque sexus in ramulis distinctis sitae a basi erecto-patenter ramosae 4–6 cm. longae densiflorae siccitate nigricantes, pedicellis late patentibus basi et medio minute bracteolatis prope florem articulatis, masculinis 2 mm. longis quam feminini dimidio brevioribus. Perianthii segmenta nigro-punctulata et -lineolata concava valde imbricata margine scariosa 2–3 mm. longa, masculina femininis paulo latiora. Stamina circiter 12, filamentis confertis capillaceis 2 mm. longis, antheris demum erectis oblongis 1.5 mm. longis. Ovarium 2 mm. longum, stylis 5–7 mm. longis, ovulo orbiculari complanato. Drupa ignota.—Haec species in genere tertia ad *A. Ruizii* Klotzsch perianthio 5-fido ad *A. cubensem* Griseb. foliis integris accedens, ab utraque inter alia spinis inflorescentia perianthii segmentis integris staminibus indefinitis antheris primum reversis recedit.

Secus viam prope San Pedro Sula, Depart. Santa Bárbara, Honduras, alt. 200 m., Maj. 1890, *Carl Thieme*, n. 5606 ex Pl. Guat. etc. quas ed. Donn. Sm.

BALTIMORE, MD.

INFLUENCE OF PHOSPHATE ON THE TOXIC ACTION OF CUMARIN[1]

J. J. Skinner

In connection with a study of the different effects produced as the result of the action of several organic compounds on seedling wheat, presented in a former paper,[2] it was noted that the presence of phosphate in the nutrient solutions employed was able to minimize or entirely overcome the toxic effect of the cumarin on the seedlings. The effects of the cumarin on plant development are strikingly shown on the seedling wheat. The leaves are shorter and broader than is normal for wheat, and only the first leaves are usually unfolded, the other leaves remaining wholly or partially within the swollen sheath; such leaves as do break forth are usually distorted and curled or twisted. The disappearance of this characteristic behavior of the cumarin affected plants was, therefore, an additional criterion of the beneficial effect of the phosphate in the nutrient cultures, as well as the improved growth and better root development of the plants in general. The nutrient solutions contained nitrate as sodium nitrate, potassium as potassium sulphate, and the phosphate was added in the form of monocalcium phosphate.

Attention was called in the earlier paper to the fact that the observation there recorded was obtained with the calcium acid phosphate, and that the observed result may be caused, therefore, by the salt as a whole rather than by the phosphate radical contained therein, or by other specific qualities of the salt or other constituent parts, namely by its acid properties or the fact that calcium is present in the compound.

Several experiments were planned so as to eliminate the possibility of calcium producing the result noted, and to present the

[1] Published by permission of the Secretary of Agriculture.

[2] Schreiner, O., and Skinner, J. J., The toxic action of organic compounds as modified by fertilizer salts. Bot. Gaz, 54:31–48. 1912.

phosphate under different conditions, acid, neutral, and alkaline. These requirements are met by using sodium salts instead of calcium, and employing all three sodium salts of phosphoric acid, namely, the monosodium phosphate (NaH_2PO_4), which like the calcium acid phosphate of the first experiment is decidedly acid in reaction; the disodium phosphate (Na_2HPO_4), which is neutral toward phenolphthalein; and the tribasic sodium phosphate (Na_3PO_4), which is alkaline in reaction. In all other respects the culture solutions were the same in concentration and composition as described in the earlier paper, the full number of 66 cultures as there described being used, both with and without the cumarin and, as in the paper cited, comparisons are always made between solutions of like composition as far as the mineral salts are concerned. This comparison, of course, can be made between individual cultures of like composition or between groups of cultures, when members of like composition occur in both groups.

Effect of monosodium phosphate

The 66 culture solutions of equal concentration (80 p.p.m. of $P_2O_5+K_2O+NH_3$), but varying in composition as far as the ratios of phosphate, potash, and nitrate are concerned, were prepared according to the scheme presented in the earlier paper cited. The sets were always in duplicate, the one containing only the nutrient salts and considered as the normal set, the other containing in addition to the salts 10 p.p.m. of cumarin. The plants grew from October 17 to 29. The green weight at the termination of the experiment for the growth in the 21 cultures composed of mainly phosphatic fertilizer (one-half and more of the nutrients being phosphate) was 38.6 grams. Similarly the green weight of the cultures composed of mainly nitrogenous fertilizer was 42.0 grams, and in the cultures composed mainly of potassic fertilizers it was 41.8 grams. The results in the normal set were: for the mainly phosphatic fertilizers, 39.3 grams; for the mainly nitrogenous fertilizers, 49.9 grams; for the mainly potassic fertilizers, 46.9 grams. These results are tabulated in table I, which also gives the results relatively expressed in terms of the normal culture taken as 100.

It will be seen that the mainly phosphatic cultures gave a growth in the presence of cumarin which was nearly as good as in the cultures without cumarin. The growth relatively expressed was 98 per cent of the normal. With the other groups it was 84 and 89 per cent. The result with the monosodium phosphate is therefore similar to the action of the monocalcium phosphate reported in the earlier paper, a fact which is also shown by the appearance of the plants in the cultures composed of mainly phosphatic fertilizers, the plants having lost entirely the characteristic effect of the cumarin above referred to, an effect which is

TABLE I

SHOWING THE EFFECT OF THE MAINLY PHOSPHATIC, MAINLY NITROGENOUS, AND MAINLY POTASSIC FERTILIZERS ON CUMARIN

Phosphate as monosodium phosphate

FERTILIZERS COMPOSED OF 50 TO 100 PER CENT OF	GREEN WEIGHT		RELATIVE GROWTH (NORMAL =100)
	Normal	With 10 p.p.m. cumarin	
	grams	grams	
Phosphate	39.3	38.6	98
Nitrate	49.9	42.0	84
Potash	46.9	41.8	89

strongly marked in the cultures low in monosodium phosphate as well as in those low in calcium acid phosphate. This experiment, therefore, disposes quite effectively of the supposition that the calcium in the phosphate salt played any significant part in the observed action, since the same action in all particulars is possessed by the monosodium phosphate. There remains the question of the influence or action of the acid character of both phosphates in bringing about the observed result. For this purpose culture experiments in which the acid phosphates were replaced by neutral and even alkaline phosphates were made.

Effect of disodium phosphate

The plants in this experiment grew from November 1 to 12, and the results are presented in table II, the grouping being again made on the basis of the composition of the nutrient salts in the

cultures, that is, into the groups mainly phosphatic, mainly nitrogenous, and mainly potassic.

TABLE II

SHOWING THE EFFECT OF THE MAINLY PHOSPHATIC, MAINLY NITROGENOUS, AND MAINLY POTASSIC FERTILIZERS ON CUMARIN

Phosphate as disodium phosphate

FERTILIZERS COMPOSED OF 50 TO 100 PER CENT OF	GREEN WEIGHT		RELATIVE GROWTH (NORMAL =100)
	Normal	With 10 p.p.m. cumarin	
	grams	grams	
Phosphate	36.3	34.1	94
Nitrate	45.8	40.3	88
Potash	44.5	38.2	86

Here again the effect of the mainly phosphatic fertilizers is the same as with the monobasic salts already discussed, although this effect is not as marked in this experiment. There remains the trisodium phosphate of alkaline reaction to be studied in this regard.

Effect of trisodium phosphate

The plants in this experiment grew from November 29 to December 10 and the results are given in table III.

TABLE III

SHOWING THE EFFECT OF THE MAINLY PHOSPHATIC, MAINLY NITROGENOUS, AND MAINLY POTASSIC FERTILIZERS ON CUMARIN

Phosphate as trisodium phosphate

FERTILIZERS COMPOSED OF 50 TO 100 PER CENT OF	GREEN WEIGHT		RELATIVE GROWTH (NORMAL =100)
	Normal	With 10 p.p.m. cumarin	
	grams	grams	
Phosphate	37.0	33.9	91
Nitrate	42.4	34.6	81
Potash	42.9	31.7	74

These figures show that the effect of this alkaline reacting tribasic phosphate has the same effect in overcoming the toxic action of the cumarin as had the calcium acid phosphate, the

monosodium phosphate, and the disodium phosphate. The reaction of these various phosphates, and probably also the presence of the calcium, appears to modify this action, as indicated by the different figures, but it in nowise determines the effect itself. The conclusion seems warranted that the peculiar action of these phosphate salts in overcoming the toxic action of cumarin is due to the phosphate radical and not to the presence of any particular base, or the acid or alkaline reaction of the nutrient solution.

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BRIEFER ARTICLES

ABSORPTION OF BARIUM CHLORIDE BY ARAGALLUS LAMBERTI[1]

During the progress of some experimental work on loco plants at Hugo, Colorado, we were led to suppose that these legumes contained much more barium salts than other plants growing in the same localities, and presumably possessed some qualities which enabled them to withdraw more of these salts from the soil. The question arose whether an increase of the quantity of barium in the soil would be followed by a corresponding increase in the plants, and to this end a series of experiments was undertaken. These experiments were not carried out as a complete study of the question, and were discontinued after the facts were obtained which had an immediate bearing on the problems which were under consideration. While the work was only preliminary in character, the results obtained may be of interest to others, and inasmuch as this work will not be continued, it may be best to publish the facts for the use of those who may be studying similar problems. While the general plan of the experiment was outlined by the writer, the detail was carried out by Assistant HADLEIGH MARSH. A plot of ground was selected on the ranch of Mr. OLSON, near Hugo, where *Aragallus Lamberti* grew with especial luxuriance. This plot was fenced in order that grazing animals might not interfere with the progress of the experiment.

EXPERIMENT NO. 1

Six thrifty plants of *Aragallus Lamberti* were selected for barium chloride treatment, and 7 plants, somewhat smaller, were selected for a control by treatment with an equal amount of water. A shallow trench was dug around each plant. These trenches were filled daily with barium chloride solution in the case of the plants experimented upon, and with an equal quantity of water in the case of the control plants. The barium chloride was applied in a 10 per cent solution. The solution was made with water containing some sulphates, so that there was a slight precipitation of sulphate of barium when the solution was made, but it is not

[1] Published by permission of the Secretary of Agriculture.

to be presumed that this made any material difference with the amount of barium chloride in solution. Two liters of barium chloride solution were applied to each of the experimental plants daily. The 10 per cent solution was used from July 8 to July 11, 1908, inclusive. On July 13, 5.5 per cent solution of barium chloride was used. No more of the solution was applied, and on July 18 it was found that the plants treated with barium chloride solution had turned yellow and dried up, while those treated with water were still green and fresh. The grass which surrounded the trenches did not seem to be affected by the barium chloride solution. Both sets of plants were dug and dried for chemical analysis.

Unfortunately the plants treated with water were by mistake thrown away, so that no analysis could be made. However, an analysis was made of *Aragallus Lamberti* collected on the tract adjacent to the fenced patch at about the time when this experiment was going on, and this will serve as a basis of comparison, though not having the value of an analysis of the control plants. The analyses were made by the Bureau of Chemistry. The plants treated with barium chloride showed ash 41.08 per cent and barium 1.32 per cent. The *Aragallus Lamberti* collected in the area adjacent to the experimental plot showed ash 22.08 per cent and barium 0.106 per cent.

EXPERIMENT NO. 2

Inasmuch as it was shown that a 10 per cent solution of barium chloride was poisonous to *Aragallus Lamberti*, it was decided to use a very much more dilute solution and to duplicate the preceding experiment, using a 0.1 per cent solution.

In this experiment 9 plants were chosen for the barium chloride treatment, and 9 similar plants for the control experiment with water. Sixteen liters of barium chloride solution were used daily on the experimental plants, and 16 liters of water on the control plants, with the exception of one day when 14 liters were used. This experiment was carried on from August 4 to August 18, inclusive. During this time both groups of plants continued healthy and showed no effect of the treatment. On August 20 both sets of plants were dug up and dried for analysis, these analyses, as in the other cases, being made by the Bureau of Chemistry. The plants treated with barium chloride showed ash 52.26 per cent and barium 0.20 per cent. The plants treated with water showed ash 22.98 per cent and barium 0.0613 per cent.

EXPERIMENT NO. 3

In the third experiment, the barium chloride was used in a 1 per cent solution. As in the preceding experiments, one group of plants was watered with the barium chloride solution and the other with an equal amount of water. Sixteen liters of the barium chloride solution and of water, respectively, were used daily in this experiment. This was commenced on September 15, and was continued to September 21, inclusive. At this time both groups of plants were in good condition, showing no ill effects from the treatment. On September 22 the plants were dug up and dried for analysis. The analyses, made by the Bureau of Chemistry, showed the following results: the plants treated with barium chloride, ash 37.095 per cent, barium 0.636 per cent. The plants treated with water showed no barium.

RESULTS

These preliminary experiments appear to show the following results: That plants of *Aragallus Lamberti* endure barium chloride solution as strong as 1 per cent with no bad effects, while a 10 per cent solution is distinctly poisonous. Grouping the analyses, we find that the largest amount of barium was found in those that were treated with the 10 per cent solution, a less amount in those treated with the 1 per cent solution, and a still less in those receiving the 0.1 per cent solution. In other words, it appears that in these experiments the quantity of barium salts absorbed varied directly with the amount in the soil.—C. DWIGHT MARSH, *Bureau of Plant Industry, U.S. Department of Agriculture.*

CURRENT LITERATURE

BOOK REVIEWS

Lotsy's textbook

The first part of the third volume of LOTSY'S *Vorträge über botanische Stammesgeschichte*[1] begins with the Coniferae and ends with Casuarinaceae. There are 1055 pages and 661 figures, scarcely any of which are original. The principal literature, especially the morphological, is gathered together and illustrations are lavishly reproduced, often whole plates, rather than merely the figures bearing upon the subject. In the case of such an extensive work it would be impossible to give any lengthy summary or to discuss even the principal conclusions, but a few points might be noted.

In concluding the 286 pages devoted to Coniferae, he finds that the phylogeny is still uncertain, but that they must have come from the great Filicales complex, and that they contain forms in which the ovulate structures should be called a flower and others in which they constitute an inflorescence; consequently, those who are convinced that the angiosperms have come from the Coniferae are at liberty to regard the angiosperm flower as either a strobilus or an inflorescence. LOTSY continues in his previous belief that the Gnetales have not given rise to the angiosperms, but rather represent the end of an evolutionary line.

The monocotyledons, with the exception of the Spadiciflorae, which LOTSY places near the Piperales, form a consistent group, and have been derived from the dicotyledons. The Alismaceae are regarded as the most primitive family and the Orchidaceae as the most advanced. The various families are considered seriatim, and their external habit and internal morphology are well illustrated, but there is little effort to show general tendencies.

Attention may also be called to a few details. In considering Gnetales, COULTER'S interpretation of the tissue at the base of the free nuclear embryo sac is questioned, but no new evidence is introduced. In the opinion of the reviewer, COULTER'S interpretation is correct and LOTSY'S own preparations would show the boundary of the embryo sac between the free nuclear portion and the so-called antipodal region.

Miss PACE'S interpretation of the embryo sac of *Cypripedium* is also questioned, LOTSY regarding the two cells resulting from the first division of the

[1] LOTSY, J. P., Vorträge über botanische Stammesgeschichte, gehalten an der Reichsuniversität zu Leiden; ein Lehrbuch der Pflanzensystematik. Dritter Band: Cormophyta Siphonogamia. Erster Teil. 8vo. pp. 1055. *figs. 661.* Jena: Gustav Fischer. 1911. *M* 7.14.

megaspore mother cell as two megaspores. This is a surprising conception of the megaspore, for it would mean that a megaspore (and presumably a microspore) could be formed with only one of the reduction divisions, that is, the megaspore would be completely formed at the close of the heterotypic mitosis. Cytologists will hardly accept such an interpretation.

The angiosperm embryo sac is interpreted as consisting of micropylar and an antipodal archegonium. This is another view which can hardly be accepted by one who has followed the gradual reduction of the female gametophyte from the bryophytes to the spermatophytes.

The book brings together an immense amount of material and will be useful just as an encyclopedia is useful. In such voluminous publications originality is not to be expected. There is a general index and an index of plant names. Many references to literature are given in the text, but the complete bibliography will be deferred until the work is complete.—CHARLES J. CHAMBERLAIN.

MINOR NOTICES

Forestry in Indiana.—The annual report of the Indiana State Board of Forestry[2] for the past year contains two papers of more than usual interest. The shorter, by STANLEY COULTER, contains a valuable mass of data on the rate of growth of various native tree species found upon the state reservation. Its study should make the selection of the best species for forest planting an easier matter, while at the same time it serves to emphasize the importance of conserving what has been the product of centuries of plant activity.

The longer article, by C. C. DEAM, the secretary of the board, is an illustrated descriptive list of the tree species native to the state and occupies 270 pages of the report. Excellent botanical descriptions of some 125 species are supplemented by full-page drawings of leaves and fruit, together with notes upon the economic uses and horticultural value of the trees, making it a valuable handbook of the forests of the state.—GEO. D. FULLER.

NOTES FOR STUDENTS

Recent work among gymnosperms.—STILES[3] has investigated some material of *Podocarpus*, *Dacrydium*, and *Microcachrys*, and has made it the basis of a synthetic presentation of the classification, morphology, history, and phylogenetic connections of the group. The bringing together of this wealth of details in an organized form will serve the very useful purpose not only of suggesting genetic connections but also of indicating the important gaps in our knowledge. The general features of the group are summarized clearly and compactly under the categories of vegetative organs, spore-producing

[2] Eleventh annual report of Indiana State Board of Forestry for the year 1911. pp. 372. *pls.* 133. Indianapolis: Wm. B. Burford. 1912.

[3] STILES, WALTER, The Podocarpeae. Ann. Botany **26**:443–514. *figs.* 8. *pls.* 46–48. 1912.

members, and gametophytes. The most interesting feature of every such review of all the available knowledge in reference to a group is the conclusion as to its phylogenetic connections. In this case it is said that "the Podocarpeae are probably related to the Araucarieae, and, though to a much less extent, to the Abietineae." These connections have certainly long been obvious, as well as the absence of any evidence of a close connection with the Taxeae. The following statement, however, is not so obvious: "A consideration of the available evidence shows that there is much to be said for the view that regards the Coniferales as descendants of paleozoic lycopodialean ancestors." Much may be said for this view, but none of it seems convincing.

GIBBS[4] has studied the development of the "female strobilus" of *Podocarpus*, a structure that certainly needs elucidation. It seems that the difficulties of interpretation disappear when the early stages of the strobilus are studied, thus eliminating the confusion of secondary modifications. Such a study "strikingly reveals the relationship of the axis to the strobilus or cone of Abietineae and its component parts." This includes the conclusion that the "ovuliferous envelope" of the podocarps is the equivalent of the ovuliferous scale of the Abietineae, which fuses "more and more till finally it merges in the ovular integument in *Torreya* and *Cephalotaxus*." The reduction in the strobilus organization is traced from Abietineae, through *Microcachrys* and *Dacrydium*, until it reaches its extreme expression in *Podocarpus*, in which genus, therefore, we are dealing with a much modified cone. Many details of structure are given which add materially to our knowledge of this interesting genus.

STILES[5] published a brief note on the gametophytes of *Dacrydium* before the appearance of his comprehensive paper on the podocarps noted above. The details given emphasize the resemblance of the male gametophyte to those of *Podocarpus* and *Phyllocladus*, and the closer resemblance of the female gametophyte to that of *Phyllocladus* than to that of *Podocarpus*. It is becoming increasingly evident that *Phyllocladus* is a podocarp rather than a taxad.

Miss DUTHIE[6] has investigated the anatomy of *Gnetum africanum*, a climbing species. Details are given of the structure of xylem, phloem, pith, medullary rays, cortex, latex tubes, epidermis of stem, cork, and leaves.

PEARSON[7] has investigated three species of *Gnetum* (*G. scandens*, *G. africanum*, and *G. Buchholzianum*), the study of the microsporangium and

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[4] GIBBS, L. S., On the development of the female strobilus in *Podocarpus*. Ann. Botany **26**: 515–571. *pls. 49–53*. 1912.

[5] STILES, WALTER, A note on the gametophytes of *Dacrydium*. New Phytol. **10**: 342–347. *figs. 4*. 1911.

[6] DUTHIE, AUGUSTA V., Anatomy of *Gnetum africanum*. Ann. Botany **26**: 593–602. *pls. 57–59*. 1912.

[7] PEARSON, H. H. W., On the microsporangium and microspore of *Gnetum*, with some notes on the structure of the inflorescence. Ann. Botany **26**: 603–620. *figs. 6. pls. 60, 61*. 1912.

microspore being chiefly those of *G. africanum*. The inflorescence is described and also the details of spermatogenesis from the mother cell to the microspore, the reduced number of chromosomes being 12. Great interest attaches to the male gametophyte of *Gnetum*, but the present account does not clear it up. At pollination, three free nuclei were observed in the pollen grain, which "are probably to be identified as one prothallial, one vegetative (tube), and one generative." Since LOTSY has figured three free nuclei in the pollen tube of *Gnetum Gnemon*, which were obviously a tube nucleus and two male cells, the free "prothallial nucleus" in the pollen grain is open to doubt. One would like to be sure whether *Gnetum* has eliminated prothallial tissue or not. The author says that "the germination of the microspore and the structure of the pollen grain point to a much closer degree of affinity with *Welwitschia* than with *Ephedra*," a conclusion which all other structures confirm.

Miss GORDON[8] has discovered ray tracheids, both marginal and interspersed, in old stem wood of *Sequoia sempervirens*. Since the wood of this form is primitive enough in features to suggest its comparison with root wood, the presence of ray tracheids is especially interesting.

WIELAND[9] has published an interesting account of *Williamsonia*, a genus which he has done so much to elucidate. A few years ago a problematical genus, it has now emerged clearly as a prominent Mesozoic group. An account is given of its discovery, its structure, and its phylogenetic connections. Its great range in habit, its variations in the structure of the strobilus, its variable foliage, all suggest wide relationships, and among these suggested relationships WIELAND sees emphasized his contention that the angiosperms have been derived from the Bennettitales.

The same author,[10] in continuing his studies on the trunks of *Cycadeoidea*, has discovered that some of the supposed young strobili are mature ones of reduced type. This incidentally disturbs some of the previous conclusions as to relationships among the species of *Cycadeoidea*, and especially extends our knowledge as to the range of variation in the structure of the strobilus. These reduced or simplified forms of course are more suggestive of the structure of the angiosperm flower.—J. M. C.

Inheritance of doubleness in stocks.—Doubleness in stocks (*Matthiola*) presents one of the most complicated cases of inheritance yet thoroughly studied, but Miss SAUNDERS[11] has developed a scheme which allows a consistent

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[8] GORDON, MARJORIE, Ray tracheids in *Sequoia sempervirens*. New Phytol. **11**:1–7. *figs.* 7. 1912.

[9] WIELAND, G. R., On the Williamsonian tribe. Amer. Jour. Sci. **32**:433–466. *figs.* 18. 1911.

[10] WIELAND, G. R., A study of some American fossil cycads. Part VI. On the smaller flower-buds of *Cycadeoidea*. Amer. Jour. Sci. **33**:73–91. *figs.* 11. 1912.

[11] SAUNDERS, Miss E. R., Further experiments on the inheritance of "doubleness" and other characters in stocks. Jour. Genetics **1**:303–376. *pls.* 2. *figs.* 2. 1911.

and orderly presentation of most of the facts brought to light by extensive cultures, and by means of which the results to be secured from any particular mating is capable of prediction with a fair degree of accuracy. Double stocks are totally sterile and must always be derived from singles, either self-fertilized or crossed with other singles. Single stocks are of two kinds with respect to their relation to doubleness, namely, "*no-d*-singles" which breed true to singleness when selfed or crossed with others of their own kind, and "*d*-singles" which when similarly bred always produce both singles and doubles, the doubles being generally in excess of the singles. Reciprocal crosses between *d*-singles and *no-d*-singles give unlike results, owing apparently to a difference in the genotypic constitution of eggs and sperms in the *d*-singles, the eggs being of two sorts while the sperms are all equal. Doubleness is recessive and disappears in the F_1, but when the *d*-single is the seed-parent the F_1 singles are of two sorts, some breeding true to singleness, others producing both singles and doubles. When the *d*-single is the pollen-parent, the F_1 singles are all of one kind and all give both singles and doubles in F_2. The ratios of singles to doubles in the pure-bred *d*-single race have always been suggestively near 7:9, thus indicating that the difference between singles and doubles involves two genes instead of one.

Miss SAUNDERS assumes that singleness is due to the presence of two factors *X* and *Y*, the absence of one or both of these resulting in doubleness. If these two factors were independent, the expected ratio would be 9 singles to 7 doubles, but if they are coupled according to the scheme discovered in sweet peas, etc., $n-1:1:1:n-1$, the doubles would be in excess of the singles as observed. The experimental results accord well with this assumption, and make it probable that the coupling is of the form 15:1:1:15, though possibly 7:1:1:7. The peculiar feature in stocks, however, as compared with the coupling in sweet peas, is the fact that neither *X* nor *Y* are carried by the pollen, and the coupling can show itself only in the constitution of the eggs. The crosses with *no-d*-singles resulted in an unexpectedly small number of doubles in F_2, owing, as proved by further breeding, to the fact that in the *no-d*-single race singleness is not produced by the joint action of *X* and *Y*, but of a similarly coupled pair *X'* and *Y'*. To further complicate the situation, there occurs a "sulfur-white" *d*-single race in which the plastid-color is also "eversporting" in a manner quite similar to doubleness, the pure-bred progenies always consisting of whites and creams as well as doubles and singles, the singles being all white, the doubles mostly cream but also sometimes white. The white plastids are assumed to be due to a factor *W* which is borne by only a part of the eggs and by none of the sperms. Moreover *W* is coupled with one of the factors for singleness, either *X* or *Y*. Although in the pure *d*-single strains *X*, *Y*, and *W* are carried only by the eggs, crosses between *d*-singles and *no-d*-singles of different plastid-color produced heterozygous F_1 plants in which both pollen and eggs carried the coupled series of genes.

In an appendix the author shows that the increase in proportion of doubles derivable from old seed is due to the greater longevity of the seeds which lack *X* and *Y*, and not to any change in the genotypic nature of any single seed. She also tried to separate singles and doubles on the basis of seed-characters, but was able to do this only in the sulfur-white race, and then not by the character for doubleness, but by the white or cream plastid-color, which as stated above proved to be coupled with one of the factors for singleness. Ten-week stocks are much branched and the Brompton stocks unbranched. The unbranched condition is recessive, but the ratio is somewhat modified because typically unbranched plants will develop some branches when the terminal bud is injured. Notes are also appended regarding the inheritance of several sap-colors, rose, lilac, terra-cotta, carmine, and crimson.—GEO. H. SHULL.

Biology and taxonomy of Gymnosporangium.—A monograph treating of *Gymnosporangium* both in its biological and its taxonomic aspects is the outcome of several years of experimental and observational work on that genus by KERN.[12] The work is divided into two parts, the first dealing with the biology and the second with the taxonomy of the genus.

In Part I the biology of the genus is discussed under the following general heads: Introduction (including the life history, general characteristics, and nuclear phenomena), distribution and relationships, experimental investigations of life histories, and pathological and economic importance. Particular attention is given to the geographical distribution of the species with reference to the distribution of their hosts. The main facts are arranged in convenient tables. The forms associated with the two sections of *Juniperus* present the most interesting features in regard to their distribution. The species which occur on the section *Sabina* belong either exclusively to the western or exclusively to the eastern hemisphere, while of those occurring on species of the section *Oxycedrus* some are common to both hemispheres and others are limited to one hemisphere. These facts lead the author to the conclusion that the forms found on the older section (*Oxycedrus*), some of whose species are distributed over all the continents of the northern hemisphere, were distributed with their hosts "during a geological period when the land conditions permitted migrations between the northern continents." The author supposes that the section *Sabina* has developed from the section *Oxycedrus* since the continents have become isolated, therefore "we would not expect to find the same species, either of hosts or fungi, indigenous in North America and in the Old World; and this, indeed, is the case." This view of course implies the independent origin of species of the section *Sabina* in the two hemispheres.

Regarding the limited geographical distribution of species of *Gymnosporangium* in cases where both the hosts have a wider distribution, no satis-

[12] KERN, FRANK DUNN, A biologic and taxonomic study of the genus *Gymnosporangium*. Bull. N.Y. Bot. Gard. **7**:392–494. 1911.

factory conclusions can be deduced from the data at hand. The apparently limited distribution of the fungus may merely indicate a scarcity of collections. A table indicating distribution of the species shows in general that the teleutospore generation is more restricted as to its hosts than the aecidial generation. Only 4 genera (5 if the two sections of *Juniperus* are considered as genera) serve for hosts of teleutospores, while 15 genera serve as aecidial hosts, *Crataegus* and *Amelanchier* being in the lead among these. While the aecidial generation has always been regarded as confined to the *Pomeae*, the work of recent years has shown that one form has aecidia on *Gillenia* (*Porteranthus*) of the Spiraeeae, and another on *Fendlera* and *Philadelphus* of the Saxifragaceae, while *G. bermudianum* is autoecious.

Part II comprises the systematic treatment of the genus, 40 species being recognized and described, the descriptions being in most cases accompanied by figures of spores or peridial cells showing characteristic features. Of the 40 species known in the world, 29 are known in their complete life cycle, 7 are known only in their aecidial phase, and 4 only in their telial phase. *Gymnosporangium fraternum*, *G. juvenescens*, and *G. effusum* are described as new, and the aecidial hosts of three species are reported for the first time. The taxonomic treatment is preceded by two sets of keys based respectively on the characteristics of the fungus and on those of the hosts. Most of the species are admirably illustrated by halftone plates.—H. HASSELBRING.

Inheritance of root-form and color in beets and turnips.—The large number of varieties of beets and turnips characterized by distinctive forms and colors of the roots has long invited the attention of experimental breeders, but the very abundance of material has doubtless acted as a deterrent to genetic investigation. KAJANUS[13] has undertaken the difficult task of analysis. As a first approximation to a complete solution of hereditary form-relations in beets, he finds the probable existence of six independent genes affecting the form, namely, two genes (L_1 and L_2) which produce an elongation of the roots, two (A_1 and A_2) which cause the roots to be taper-pointed below, an inhibitor (B) which opposes the action of the elongation-genes, and another (O) which opposes the action of the taper-point genes. When B and O are not present, the long and tapered forms are epistatic over the short and blunt forms, but when these inhibitors are present, the apparent dominance is reversed. The evidence for the existence of these genes consists at present wholly in the occurrence of the ratios 3:1, 15:1, and 1:3 in the F_2. In most of the reported crosses the results run fairly close to these ratios, but

[13] KAJANUS, B., Genetische Studien an *Beta*. Zeitschr. Ind. Abst. Vererb. **6**:137–179. *pls. 9. figs. 2.* 1911.

———, Mendelistische Studien an Rüben. Fühlings Landwirthsch. Zeitg. **61**:142–149. 1912.

———, Genetische Studien an *Brassica*. Zeitschr. Ind. Abst. Vererb. **6**:217–237. *pls. 4.* 1912.

when so many determiners affect the same character, the F_2 ratios are only suggestive and not decisive. Until a third and perhaps still later generations have been grown, the assumptions made by the author remain hypothetical, but with the weight of the observed F_2 ratios in their favor. In the Brassicas studied, the situation appears to be much simpler. In the turnip-rooted cabbages or Swedes (*B. Napus*) the roots are always approximately globular, but in the turnips (*B. Rapa*) both globular and elongated forms occur and there appear to be, just as in beets, two elongation genes (L_1 and L_2). Here again the evidence for these two genes is the appearance of the long and round forms in the F_2 in the ratio 15:1, and a later generation must decide the correctness of the interpretation.

In regard to the color of the roots the situation is also quite complex, perhaps even more so than in respect to form. Red is in some cases dominant to its absence, in other cases recessive (owing probably to the presence of an inhibitor), and it may appear in crosses between two whites, white and yellow, rose and yellow, etc., showing its compound nature. Some of the color-ratios are approximately 15:1 and others 3:1, which are also interpreted as indicating the existence of more than one gene capable of producing independently the same color-character. In turnips the upper portion of the roots is red, green, or yellow, each of these colors being epistatic to those following. The lower portion of the roots is white or yellow, having the same color as the flesh, the white being epistatic to yellow. In the turnip-rooted cabbages the heads are either violet-red or green. There are two independent genes which produce violet-red pigmentation, the one giving a light red, the other a dark red. As the latter is completely epistatic over the lighter color, a cross in which both of these genes and their absence are involved, produces an F_2 progeny consisting of dark red, light red, and white, in the ratio 12:3:1. Both in form and color the heterozygotes are often intermediate, so that a more or less completely continuous series of forms is produced, thus making the analysis difficult. This fact makes very important the promised continuation of the work.—GEO. H. SHULL.

Inheritance in wheat.—NILSSON-EHLE[14] gives a further report on his long-continued experiments in the crossing of wheat varieties, dealing this time especially with the density of the spikes and resistance to yellow rust (*Puccinia glumarum*). Both of these characters are lacking in the definiteness which has made the study of many alternative characters easy and the results clear-cut and decisive, but the author's earlier demonstration of several independent genes producing the same apparent character in seed-color of wheat and in the awns of oats has given a key to these more difficult cases. The density of the spikes is apparently modified by three distinct genes, two of which (L_1 and L_2)

[14] NILSSON-EHLE, H., Kreuzungsuntersuchungen an Hafer und Weizen. II. Lunds Universitets Årsskrift. **7**:no. 6. pp. 84. 1911.

promote elongation of the heads, while the third (*C*) acts as an inhibitor which checks the longitudinal development of the heads. When all of these factors are absent, a moderately dense head results, as exemplified by the "squarehead" varieties. When *C* is present and both L_1 and L_2 are absent, the extremely dense "compactum" form is produced. Although considerable transgressive fluctuation renders the analysis doubtful in individual cases, the total result is sufficiently decisive to leave little doubt of the essential correctness of the interpretations. The discovery that several genes may affect quantitatively the same external characteristic has given an explanation of some hybrid progenies which have seemed to breed true to characters intermediate between the parents, and it also explains the intensification of parental characters in F_2 individuals which have often been observed. As an example of the latter phenomenon, a cross between two wheats of intermediate density, having the formulae CL_1L_2 and cl_1l_2, produces some F_2 plants with very dense heads (Cl_1l_2), and some with very lax ones (cL_1L_2). In respect to rust-resistance, the difficulties of analysis are still greater and the author makes no attempt to identify particular genes, but the results of a large number of tests in second and third generations show very clearly two important facts, namely, that there is a segregation of different grades of resistance in the F_2, and that the matter is not generally as simple as BIFFEN found it to be in his crosses dealing with this problem. In none of NILSSON-EHLE'S crosses was there an indication of a simple monohybrid ratio (**3:1**) for rust-resistance, as was found by BIFFEN.

KAJANUS[15] reports an instance in which the *spelta*-character (zigzag rachis and adherent glumes) is recessive to the *vulgare*-character (straight rachis and free glumes), a situation exactly the reverse of that found by von TSCHERMAK. This indicates that there are two genotypes of one or the other of these two phenotypes, thus paralleling the now frequently demonstrated existence of dominant and recessive whites. KAJANUS found presence of awns recessive to their absence, and hairiness of the glumes dominant to its absence, as in all other reported crosses in which these characters have been involved. —GEO. H. SHULL.

Cytology and sexuality of Olpidiopsis.—Overcoming considerable difficulties in the matter of obtaining and managing material, BARRETT[16] has greatly increased our knowledge of the cytology and especially of the sexuality of the submerse chytrids. Three species of *Olpidiopsis*, parasitic on *Saprolegnia* and *Aphanomyces*, were studied, two of which (*O. vexans* and *O. luxurians*) are described as new. The first part of the paper consists of biological observations, among which will be found many valuable suggestions to anyone undertaking similar work. The zoospores are shown to have two equal flagella

[15] KAJANUS, B., Zur Genetik des Weizens. Botaniska Notiser 1911:293–296.

[16] BARRETT, J. T., Development and sexuality of some species of *Olpidiopsis* (Cornu) Fischer. Ann. Botany **26:** 209–238. *pls. 23–26.* 1912.

springing from the same point, although one is directed backward and sidewise in such a manner as to give the appearance of the short lateral cilium that has hitherto figured in the descriptions of this and some other genera of biflagellate Archimycetes. They are distinctly diplanetic and show a pulsating vacuole during the interval between the two periods of activity. Soon after infection the young parasites are lost to view in the host protoplasm, but retain their individuality and develop into zoosporangia without fusing to form plasmodia.

The parasite becomes coenocytic by nuclear division on the beginning of growth. The nuclei, which show the complete concentration of the chromatin into the karyosome characteristic of most chytridiaceous nuclei, appear to divide exclusively by mitosis of a type not very dissimilar from that of *Synchytrium*, but no astral bodies were seen. The chromosomes are approximately six in number. Segmentation is believed to be simultaneous, and begins at least before the sporangium enters the period of rest which it often undergoes before sporulation. The formation of resting spores was found to be dependent on conditions in the culture which are described. The small adjacent cells are definitely shown to be antheridia and the transfer of their coenocytic protoplasm to that of the egg is figured. The number of nuclei of the gametes unfortunately is not stated, but one would judge from the figures that it approximates 100. The fate of the male pronuclei after entering the egg could not be definitely followed, but it is believed that they fuse in pairs with the female pronuclei. The author concludes that "these forms seem to be primitive sexual organisms of the oomycete type. The influence of external conditions on the development of the sexual stage, the mode of fertilization, the unequal size of the two gametes, and the apparent morphological equivalence of these gametes with the sporangia, seem to the writer to point to that assumption."—ROBERT F. GRIGGS.

An epiphytic Tillandsia.—The "ball moss," *Tillandsia recurvata*, is found growing epiphytically upon many tree species in the vicinity of Austin, Texas, in such abundance as to be detrimental to its host. BIRGE[17] has found that any damage resulting to the supporting tree must be due to interferenc with the light supply, as the short holdfast roots merely furnish mechanical support for the moss, the water and salts necessary for the life of the plant being absorbed exclusively by the scale-covered leaves. A sufficient amount may be obtained from three hours dew or rain to last the plant for 38 hours. The leaves are well supplied with chlorophyll in minute oblong plastids, and the complete independence of the plant is shown not only by the entire absence of any organic connection with the living tissues of the host, but also by the fact that it thrives upon old board fences and even upon electric wire insulators. It seems to thrive best in semi-arid conditions. Shade trees may be freed from the epiphyte by scraping off the larger plants before the dissemination of

[17] BIRGE, WILLIE I., The anatomy and some biological aspects of the "ball moss," *Tillandsia recurvata* L. Univ. Texas Bull. 194. pp. 24. *pls.* 10. 1911.

the seed in January, and by the destruction of the seedlings by spraying with a 10 per cent kerosene emulsion.

The study of the morphology of the reproductive organs shows a single archesporial cell giving rise to a parietal cell, which BILLINGS says does not appear in *T. usneoides*. In four or five days after formation the megaspore mother cell begins the divisions that result in a linear tetrad; an embryo sac of the usual type is produced; double fertilization commonly occurs, and the endosperm develops as free nuclei which eventually line the sac and become separated by walls. The development of the embryo is of the usual *Alisma* or *Sagittaria* type characteristic of most monocotyledons. The dispersal of the seeds is facilitated by long barbed hairs arising from the integument, and later functioning in attaching the seeds to the substratum, upon which they speedily germinate. Under favorable conditions germination frequently occurs within the capsule before the dispersal of the seed.—GEO. D. FULLER.

Permeability.— Heretofore the power of various anilin dyes to stain living plant cells has been tested on algae, water plants, root hairs, or thin sections of organs of land plants, a method introduced by the pioneer work of PFEFFER. KÜSTER[18] conceived that surface cells as used in this method may have different permeability characters from the deeper placed ones, also that cells of land plants may have their permeability characters considerably altered by sectioning. In order to test the ability of anilin dyes to penetrate the deeper lying cells in their natural conditions, KÜSTER used twigs of some size, or at least whole leaves with petioles. The cut ends were placed in aqueous solutions of the dyes, which were carried up the xylem by the transpiration stream, and, after 24 hours sections of the organs were studied for staining of the living cells along the xylem strands. A number of anilin dyes that former workers have pronounced incapable of entering living cells KÜSTER finds by this method to be excellent *intravitum* stains. He distinguishes carefully between true *intravitum* staining and staining due to injured protoplasm. In many cases cells were not injured by many days' treatment with dyes, and dyes abundantly stored in living cells were not reduced in amount by several days' washing in running water.

His results furnish much evidence against OVERTON's lipoid theory of permeability; and in contrast to the results of RUHLAND on plant cells and HÖBER on animal cells. show, with few exceptions, a general parallelism between high diffusibility (non-colloidality) of the aqueous solution of anilin dyes and their ability to penetrate the living cell.—WILLIAM CROCKER.

Chemical unit-characters in maize.—While all inherited characters are probably referable to chemical relations brought about in the segregations and recombinations of the substance and substances of the germ cells, little atten-

[18] KÜSTER, ERNST, Über die Aufnahme von Anilinfarben in lebende Pflanzenzellen. Jahrb. Wiss. Bot. **50**: 261–288. 1911.

tion has been given thus far to the invisible chemical composition of zygotes in the generations following a cross. PEARL and BARTLETT[19] have investigated a cross between a yellow dent starchy maize and a white sweet maize, and reach the conclusion that low fat content, low protein content, low ash content, and perhaps also low crude fiber and low percentage of pentosans, are inherited as Mendelian unit-characters independent of the units which determine the externally distinguishable characters of color and starchiness. As the method of arriving at this conclusion was indirect, it was impossible to determine whether these chemical characters are also independent of each other. The low grades of all these characters are dominant over high grades. The authors assume that the absence of the genes for starchiness (*ss*) acts as an inhibitor to these chemical units. It would harmonize better with the presence-and-absence hypothesis to regard the low grades of the various chemical substances here considered as the product of the interaction of the corresponding genes with the gene for starchiness. The authors point out that the result of this investigation should lead to a revision of the usual interpretation of the oft-cited selection experiments of the Illinois Agricultural Experiment Station.—GEO. H. SHULL.

Transition from root to stem.—COMPTON[20] has published a very useful analysis of the theories of the anatomical transition from root to stem. Its text is the recent notable publication by CHAUVEAUD which COMPTON regards as marking "an important advance in the study of seedling anatomy." In these days, when many botanists are trying to orient themselves in the very rapidly developing field of vascular anatomy, such comparative statements are very helpful.—J. M. C.

Embryogeny of Ranunculaceae.—SOUÈGES has undertaken the investigation of the embryo sac and embryo of the Ranunculaceae, and the papers dealing with the Clematideae were noticed in this journal.[21] The four most recent papers in the series[22] continue the consideration of the Anemoneae, and comprise a detailed account of *Myosurus minimus*. It is interesting to have the embryogeny of this form so thoroughly worked out and so well illustrated.—J. M. C.

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[19] PEARL, R., and BARTLETT, J. M., The Mendelian inheritance of certain chemical characters in maize. Zeitschr. Ind. Abst. Vererb. **6**: 1–28. *fig.* 1. 1911.

[20] COMPTON, R. H., Theories of the anatomical transition from root to stem. New Phytol. **11**: 13–25. *fig.* 1. 1912.

[21] BOT. GAZ. **51**: 480. 1911.

[22] SOUÈGES, E., Recherches sur l'embryogénie des Renonculacées. Bull. Soc. Bot. France **58**: 542–549, 629–636. 1911; **59**: 23–31, 51–56. 1912.

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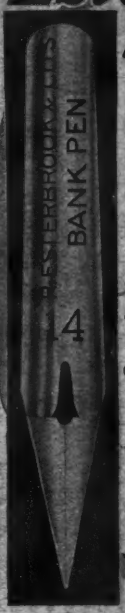

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